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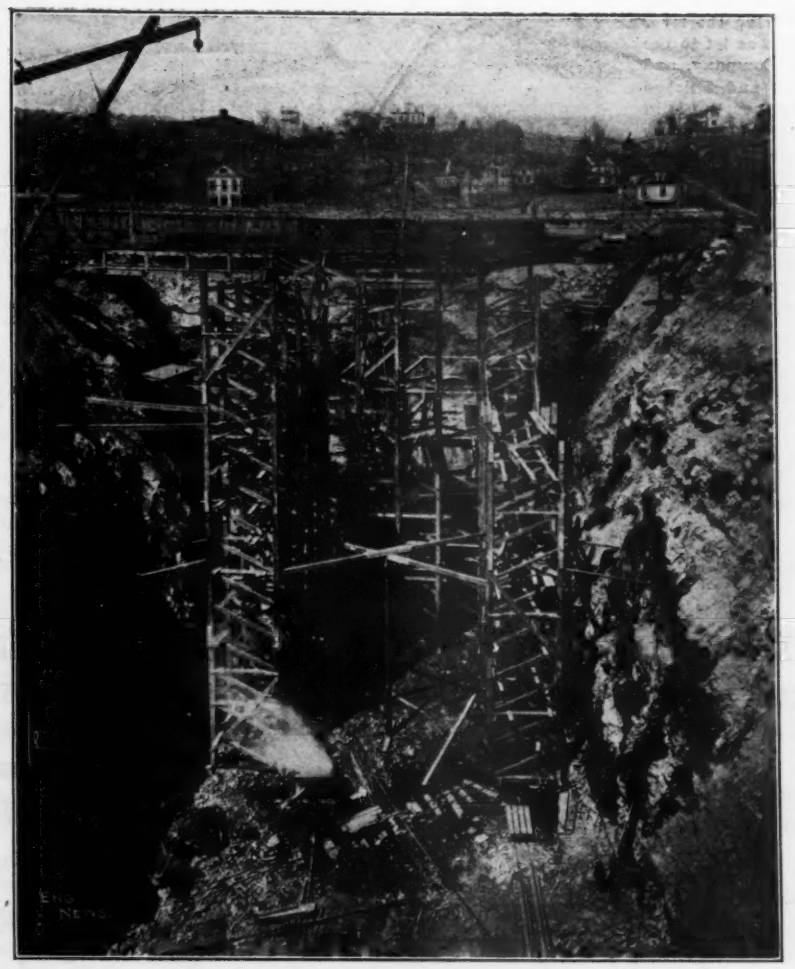
THE CONSTRUCTION OF THE PENNSYLVANIA R. R. TUNNELS UNDER THE HUDSON RIVER AT NEW YORK CITY.*

By James Forgie,† M. Am. Soc. C. E., M. Inst. C. E.

I.—Tunnel Design, Shields and Plant.

The diverted extension of the Pennsylvania R. R. beyond its eastern terminus at Jersey City, N. J., across the Hudson River (in New York this river is locally known as the North River) into the heart of the city of New York to a new terminal and thence to a connection with the Long Island R. R. has as one of its main features two single-track tunnels under the Hudson River; see the map Fig. 1. These tunnels, extending under the shores of the river, in both States, through various strata hereinafter described, and under the river through a very soft mud (Hudson silt), attaining a maximum depth of 97 ft. at invert below mean high water, and being intended for very heavy and high-speed traffic of great volume, are an undertaking with little or no precedent. In fact, these conditions make this work under the Hudson River a most puzzling engineering problem in tunnel work, and thereby probably of more interest to engineers than any tunnel work hitherto attempted. The old Hudson River Tunnel, recently completed (1904) between Morton St., New York, and 15th St., Jersey City, about 1¼ miles below, and built under to some extent similar conditions as to depth and soil, was originally intended for main-line railway traffic, but is now intended for electric rapid transit service. However, it had become evident during the work on the latter tunnel that the silt which forms the bed of the Hudson River is so soft that some degree of displacement and distortion of a tunnel can and does occur, both during and after construction; this, while not considered a serious difficulty with a traffic as light as roadway or rapid transit, would, it is judged, be a grave matter in a tunnel intended for the heavier traffic of a trunk-line railway. No means for overcoming this difficulty was considered satisfactory until, in 1901, Mr. Charles M. Jacobs, M. Am. Soc. C. E., Chief Engineer of the old Hudson River tunnel and also of the other tunnels projected or now being built under the Hudson River, conceived the plan that column foundations might be sunk through the cast-iron shell of the tunnel by means devised to prevent the entrance of silt into the tunnel. This plan offered such guarantee to the P. R. R. management for a permanently stable construction, able to resist or protect the same from the stresses caused by heavy and fast trains, that it was made the basis of plans for the tunnels for the Pennsylvania Railroad's contemplated extension into New York. Detailed plans were drawn up under Mr. Jacobs' direction, and in May, 1904, the work was put under contract. The tunnels progressed successfully, and on Sept. 12, 1906, the shields of the Weehawken (N. J.) and Manhattan (N. Y.) headings of the north tube came together, 168 ft. west of the State Line. About a month later, on Oct. 9, the shields of the south tube also met, 370 ft. east of the State line, which is practically the middle of the River. The actual driving of the subaqueous tunnels may, therefore, be considered virtually completed, although the concrete lining has not yet been placed and no foundations have been put down except to test the provisions made for them. The occasion of the completion of the tubes is thought suitable for a review of the work.



VIEW OF EXCAVATION FOR WEEHAWKEN SHAFT, LOOKING WEST, APRIL 18, 1904.

Excavation completed and part of frame for concreting in position.

A plan and profile of the tunnels of the North River Division is shown in Fig. 2. The tunnels extend from the west face of Bergen Hill, the southern end of the Palisades, eastwards to the east line of Tenth Ave., New York City, where they enter the depressed yards of the great terminal station now being constructed, a length of about 2.68 miles, or 14,171 ft. This length comprises (1) two single-track rock tunnels through Bergen Hill, 5,910 ft. long;† (2) a subequeous section, consisting of two single-track cast-iron concrete-lined tubes, which will each carry one track; (3) an approach section, extending from the subaqueous section east to the terminal station, and consisting of a twin tunnel, partly in soft ground but mainly in rock.† The east and west bound tracks are therefore entirely separated. These three sections are radically distinct in conditions and design, and were separately contracted for. The present article is concerned only with the second, the subaqueous section, which is the central feature of the entire enterprise.

The subaqueous or tube-lined portion of these tunnels is 6,118 ft. long between the chambers in which the shields were erected, and consists of two parallel lines of cast-iron circular tubes 21 ft. 2 ins. internal diameter and 23 ft. external diameter, except that several special and short lengths of the tunnel are of similar design in cast steel. Each tube will be lined with concrete, and carries a single track. Figs. 3 and 3a show typical cross-sections of the tunnel. The tubes pass under the line of 32d St., Manhattan, and under Pier 62, N. Y. C. & H. R. R. R., cross the river in two tangents joined by a very flat curve (0° 30′ curve, I = 0° 53′ 35″), at a distance apart of 37 ft. center to center, and reach the shaft at Weehawken, after passing under the slip between Piers B and C of the Erie R. R., Weehawken. The maximum depth of the tunnel invert below mean high water is about 97 ft.

The river tunnels section, of which the New York half is being built by the Pennsylvania,

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†Chief Assistant Engineer, North River Division, P. R. R. New York Extension, Pennsylvania, New Jersey & New York R. R. and Pennsylvania, New York & Long Island R. R.

†For cross-sections of these tunnels see Engineering News of Oct. 15, 1906, p. 331 et. seq.

New York & Long Island R. R., the New Jersey half by the Pennsylvania, New Jersey & New York R. R., includes, besides the length between shield-chambers, also a short stretch of rock tunnel at either end, between the shield-chambers and the construction shafts. The two shafts were built in advance, on separate contract, and were turned over to the tunnel contractors complete. Their location is shown in Fig. 1. The total horizontal distance between shafts is 6,550 ft., measured on the center line between the two tubes. In this length the tunnel passes through rock, water-bearing sand and gravel, piling and riprap and other artificial obstructions, and the soft river silt characteristic of the Hudson. These materials are indicated in the profile, Fig. 2.

The contract for the work, from the Manhattan shaft to the Weehawken shaft, was let to the O'Rourke Engineering Construction Co., and was signed on May 2, 1904. The contractors started work at the Manhattan shaft on April 1, 1904, and at the Weehawken shaft on September 1, 1904. The contract time for completion, including concrete lining and column foundations in place, is three years.

WORK DONE PREVIOUS TO SHIELD WORK.

Before describing in detail the subaqueous work that has progressed so far, as noted above, it may be well to briefly describe some of the preliminary shaft and heading work done during the consideration of the tunnel designs to accelerate, as far as might be, the work of driving the river tunnels. The contract for this work was let to the United Engineering & Contracting Company, and was commenced on June 11, 1903, and finished on Sept. 1, 1904. This chiefly consisted in providing the contractors both for the river tunnels and the tunnel under Bergen Hill with shafts ready for their occupancy so that the time which they would have taken to sink shafts was saved. There are two such shafts, one at Manhattan and the other at Weehawken. Fig. 2 roughly indicates their location. The Weehawken shaft is directly over the center line, and is wide enough to include both tubes. The Manhattan shaft is about 100 ft. north of the center line of the tunnel, and is connected with it by a cross-drift. Table I. (see opposite page) gives some main figures relating to the shafts.

The sinking of of the Manhattan shaft was accomplished without any difficulty or special incident; the work also included the driving of two 8 × 10-ft. cross drifts across 32d St. to expedite the commencement of the main tunnels directly the contract was let.

The sinking of the Weehawken shaft was a much larger piece of work and involved a considerable amount of difficult excavation and concreting. During the fall and winter of 1903 the shaft was several times flooded by a combination of high tide, heavy rain, and bursting of a main sewer, and the treacherous rock and dirt faces either collapsed or were prevented from doing so by careful watching and timbering where necessary. The shaft as originally designed was 116 ft. 4 ins. long by 52 ft. 7½ ins. wide at the bottom, and 170 ft. × 100 ft. at the top, and was intended to be lined with concrete down to the surface of the rock, which was from 6 to 30 ft. below the general surface of the ground. However, during excavation and notwithstanding the exploratory borings which indicated reasonably good self-supporting material, the rock was found to be so rotten and disintegrated (the junction of the trap of the Palisades and the sandstone country-rock occurring at about one-third of the length of the shaft from

Pennsylvania R. R. New York Extension
Elevated Lines.
1. Brooklyn Bridge.
2. Williamsburg Bridge.
3. Blackwell's Isl. "
4. Manhattan "
5. First Hudson R. Tunnels
6. Cortlandt St. "
7. P.R.T. East River "
8. N.Y. Rapid Transit Lines.
9. Steinway Tunnel.
0 1 2 3 4 5 6 7 8 9 10
Miles.
ENG. NEWS.

FIG. 1. MAP OF NEW YORK AND VICINITY, SHOWING LOCATION OF PENNSYLVANIA R. R. EXTENSION INTO NEW YORK BY WAY OF TUNNEL UNDER THE HUDSON RIVER.

The new Pennsylvania Terminal, now being built, is at 31st to 33d St., fronting on Seventh Ave., and with its tracks extending west 1,400 ft. to Ninth Ave. A four-track line in subway extends east from the terminal, passing under the East River in a group of four single-track tunnels, to a connection with the Long Island R. R. in Long Island City. This is a vital element in the New York extension. Work on every part of this enterprise has been in rapid progress for two years past.

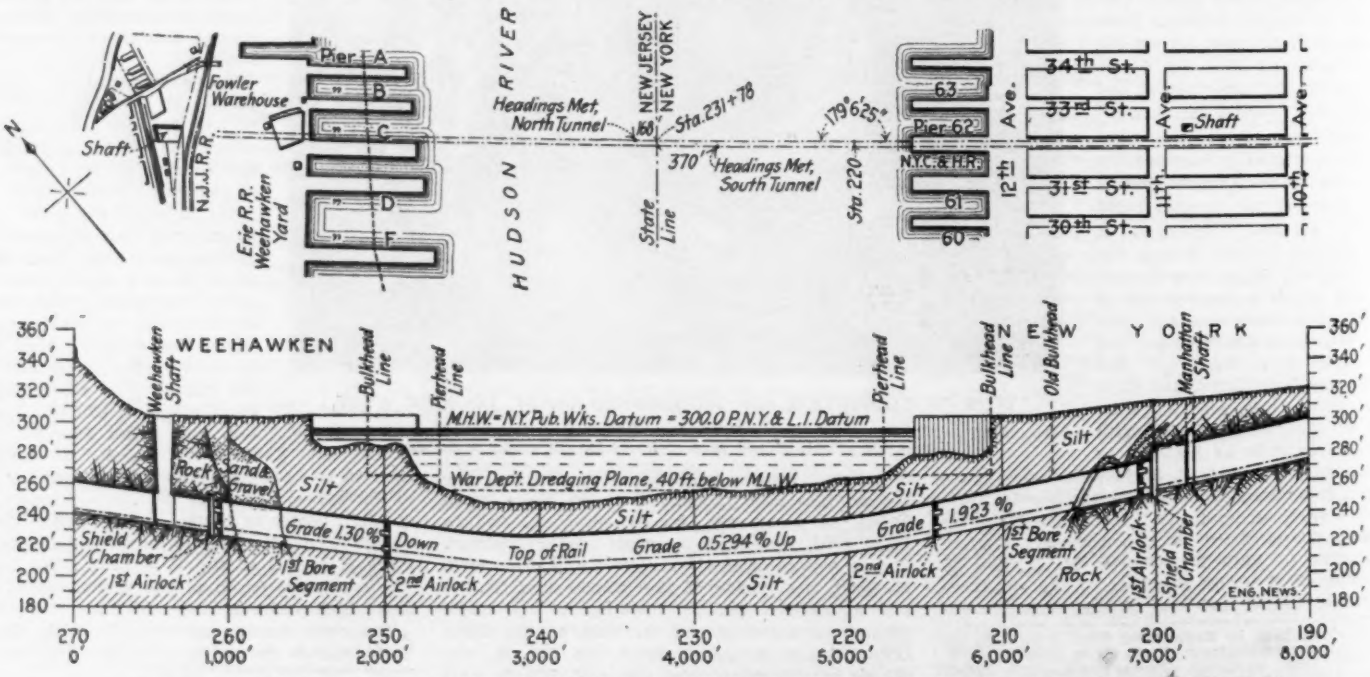


FIG. 2. PLAN AND PROFILE OF PENNSYLVANIA R. R. TUNNELS UNDER THE HUDSON RIVER AT NEW YORK, N. Y.

its west end) that it was decided to carry the concrete walls down the whole depth of the shaft and also to excavate a length of 40 ft. of the tunnels both east and west of it, to insure the safety of the end walls, which had necessarily to be retaining walls. Fig. 4 is a drawing of the shaft as built, while the half-tone view Fig. 6 reproduced from a photograph, shows the shaft as it appeared when completed.

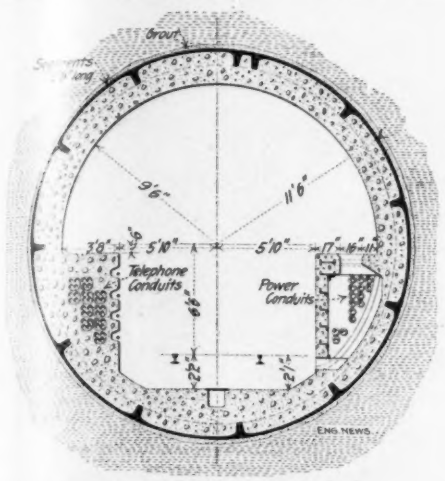
This modification caused the expenditure of more time and money than was originally intended, but the result is a very satisfactory piece of work. It may be added as a further item of interest that tunnels for the length occupied by this shaft would have cost only 50% less than the shaft cost. Great care was given to the drainage of the wall, vertical open joint vitrified drains being built in at the back at frequent intervals, with the result that the shaft is quite dry. Much attention was also paid to the securing of a smooth face and a mortar facing was simultaneously placed with the concrete en masse. The side walls were merged with the rock with the assistance of steel-tie rods as shown and the extensive nature of the framing necessary for the concrete forms is seen in the photograph on the first page and the later view, Fig. 5. The east and west walls are proportioned as retaining walls, while the side concrete walls, apart from the upper portions of them, are intended as lining reinforcing the rock, which is stepped off to match the face slope approximately or as the nature or cleavage of the rock would permit.

SHIELD CHAMBERS. — The chambers in which the Weehawken shields were erected were simple pieces of rock excavation not requiring timbering. In the case of the Manhattan chambers, though they were in rock, the cover averaged about 6 ft. in thickness; and as the nature of the rock was unknown and liable to sudden change, it was necessary to excavate and timber with great care, as the span was about 60 ft.

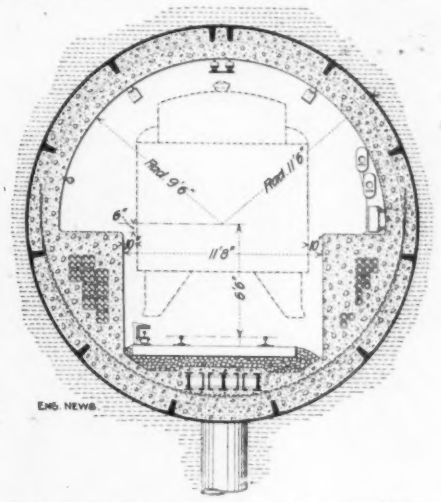
Fig. 7 shows the general arrangement of the timbering used, also the progress of the excavation (the sequence of this is indicated by figures (1) (2) &c) and the form of the cast-iron lining. As a matter of fact the major part of the rock roof, though thin, proved to be of good sound granite and up to the time that the cast-iron lining was in place and the space above packed tight, it could not be seen that any weight had come on the timbers. The cast-iron lining was put in place by a simple and convenient erector built of timber, which appears in the photograph Fig. 8.

The only notable incident occurring during the execution of this piece of work was that while excavating the west end of the south side top drift the rock was penetrated to the soft ground which at that point came down in a pocket. This occurred at 2 o'clock in the morning of Oct. 20, 1904. Water poured into the workings and caused a cave-in to occur under one of the tracks in the New York Central railroad yard. The cavity at the surface was soon filled in, but some difficulty was experienced in regaining the face of the heading and stopping the loose ground and water from entering the tunnel.

Preliminary to a later description of the pneumatic work, that is, the construction of the tunnels from the shield-chambers outward, it will be necessary to describe the lining or shell and the shields in some detail, as on these depend directly or indirectly all features of the work. Mention will also be made of the power-plant and the principal working appliances used.



Section in Sand and Gravel or Rock

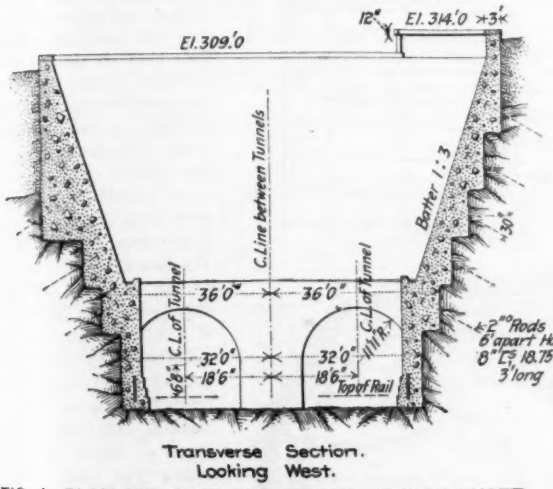


Section in Hudson River Silt, with foundations

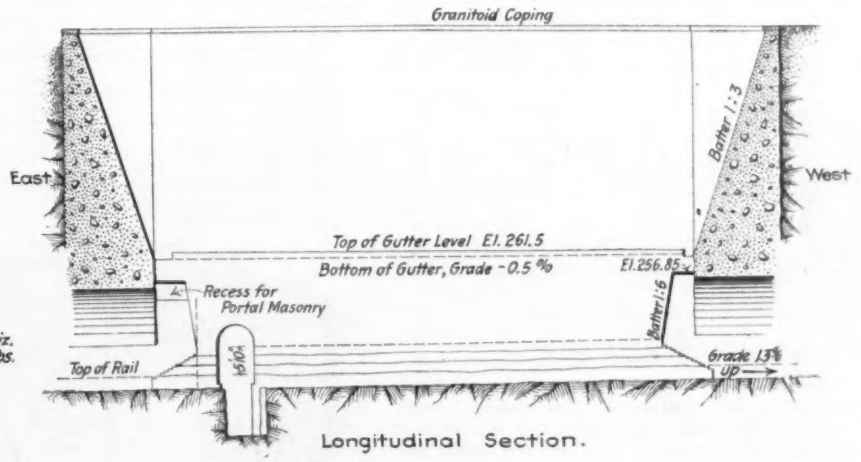
FIGS. 3 AND 3A. TYPICAL CROSS-SECTIONS OF ONE TUBE OF PENNSYLVANIA R. R. TUNNELS UNDER THE HUDSON RIVER.

TABLE I.—PARTICULARS OF SHAFTS ON THE NORTH RIVER TUNNEL OF THE P. R. R. TUNNELS INTO NEW YORK.

Location.	Depth ft.	Width ft.	Length ft.	Excavation including drifts, cu. yds	Concrete cu. yds.	Date com.	Date fin.	Ground met.	Lined with
Manhattan, 11th Avenue and 32d St.	55	22	32	2,010	209	June 10, 1903.	Dec. 11, 1903.	Top 13 ft. filled rest granite and mica schist.	Concrete reinforced with steel beams down to rock.
Weehawken, Baldwin Ave.	76	at bottom 56 at top 100	115.75 154.	55,315	9,810	June 11, 1903.	Sept. 1, 1904.	Sand and hardpan at top for irregular depths (6 to 30 ft.) decomposed rock, trap and sand stone below.	Concrete with steel-rod-bond to rock.

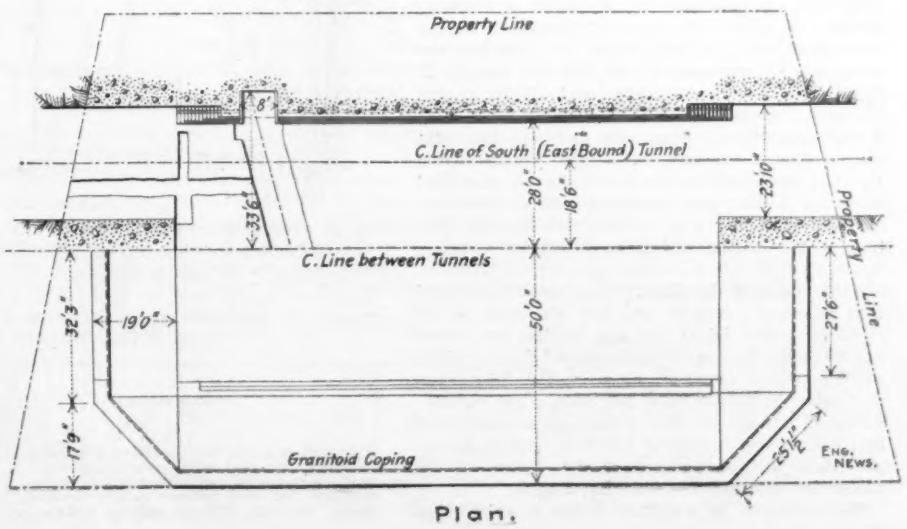


Transverse Section. Looking West.



Longitudinal Section.

FIG. 4. PLAN AND SECTIONS OF WEEHAWKEN SHAFT.



Plan.

Tunnel Lining.

The tunnel shell is formed by cast-iron circular lining, of the segmental bolted type, long the standard for shield-driven tube tunnels. In some special cases, cast-steel was used in place of cast-iron.

The length of ring employed is 30 ins. The choice of this length was chiefly due to the consideration of provision for the column foundations to be sunk through the bottom of the tunnel; it represents a notable increase over the ring-length employed in previous cast-iron lined tunnels, excepting the Blackwall tunnel under the Thames, as exhibited by the following partial list.

	Length of ring, ins.
Tower Subway, London, Eng.	18
East River Gas Tunnel, New York	16
Baker St. & Waterloo Ry., London	18
Glasgow Harbor Tunnel, Glasgow	18
Glasgow District Subway, Glasgow	18
St. Clair Tunnel (Grand Trunk Ry.), Port Huron, Mich.	18¼
City and South London Ry., London	18, 19 and 20
Central London Railway, London, Eng.	18 and 20
Waterloo & City Ry., London	18 and 20
First Hudson River Tunnel, New York	20
Brompton & Piccadilly Railway, London	18 and 20
Great Northern & City Railway, London	18 and 20
Great Northern & Strand Railway, London	18 and 20
Blackwall Tunnel, London	30
P. R. R. East River Tunnels, New York	30
P. R. R. Hudson River Tunnel, New York	30

Two kinds of cast-iron lining are used, distinguished as "ordinary" or standard and "heavy." The former is a structure of sufficient strength and the latter was adopted under the river as the best means (by its weight) of counteracting the effect of suspected buoyancy in the quasi-fluid silt. In both kinds the ring has the same overall dimensions, viz., 30 ins. length, 21 ft. 2 ins. internal diameter and 23 ft. 0 ins. external diameter, and consists of nine A-segments, two B-segments and one key segment. The B-segments are those which adjoin the key and which, therefore, have one end joint not radial, but formed so as to make an opening 12.25 ins. wide at the outside and 12.60 ins. at the inside which is closed by the key segment.

Each segment is about 77½ ins. in external circumferential length, and has six bolts in the circumferential joint; the key having one, there are 67 bolts in one circumferential joint. Each of the twelve longitudinal or radial joints has five bolts, in all 127 bolts per ring. The circumferential flanges of each plate are strengthened by two transverse webs or feathers on each flange. All important particulars of the design of the lining are given in the drawing, Fig. 9.

The ordinary or standard lining is subdivided into two different sorts known as "pocket" and "pocketless." The difference between the two is that in the pocket type the calking groove (mentioned hereafter) extends behind the bolt holes, which, as the bolts are necessarily not a machine fit, are always a leaky source of trouble, while in the pocketless type the groove is confined to the edges of the plates, as shown in Fig 9. The use of the pocket iron was confined to actively water-bearing ground as rock, gravel, sand, etc., and when the tunnels entered the true Hudson River silt its use was not adopted, as experience has shown that in this silt tunnels can be made water-tight with the simple or pocketless groove.

The ordinary type of lining was also made in cast-steel, and this was used in two different places, both on the Manhattan side: (1) Where the rock disappeared from the invert of the tunnel and gave place to silt, the cast-steel lining was used to give greater strength to the tunnel at the point where the supporting ground passed from a stable to that of less stable character; 40 ft. of tunnel in each tube was thus built of steel. This was not done at Weehawken, as the end of the rock did not coincide with the beginning of a silt bottom, but was succeeded by sand and gravel, and thus the transition was not so sudden. (2) The other place at which cast-steel lining was used, also on the Manhattan side, was where each tube passed under the river bulkhead wall, the steel being used to give greater strength to support this structure; 37½ ft. were thus built of steel in each tunnel, which gave 7½ ft. of steel-lined tunnel on each side of the river wall.

FIG. 5. VIEW IN WEEHAWKEN SHAFT, LOOKING EAST ALONG SOUTH WALL, JUNE 14, 1904. CONCRETING SOUTH WALL.

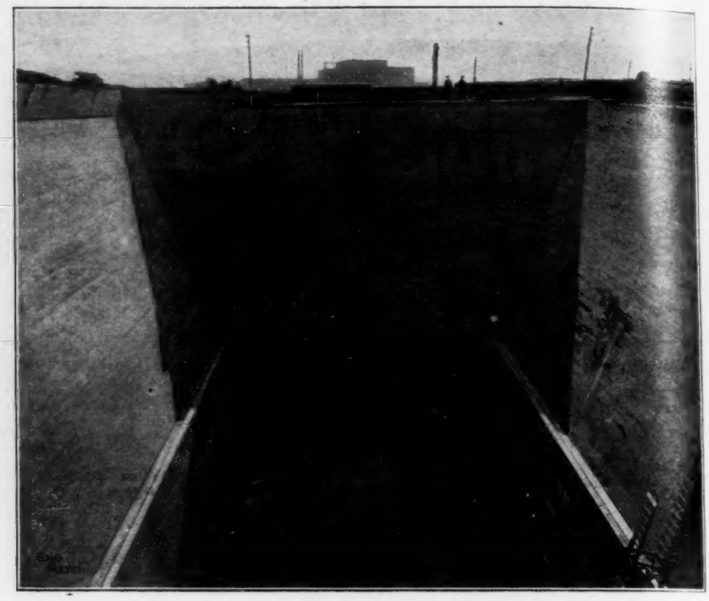


FIG. 6. VIEW OF COMPLETED WEEHAWKEN SHAFT, LOOKING EAST FROM TOP, SEPT. 8, 1904.

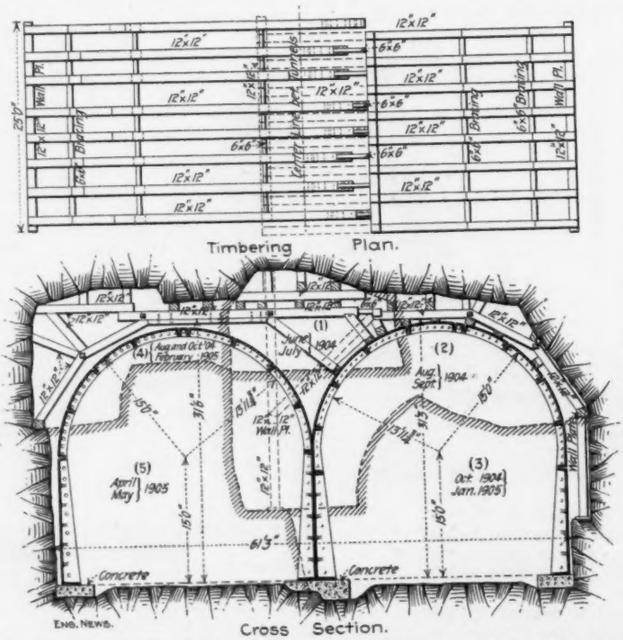


FIG. 7. DIAGRAM OF PROGRESS OF EXCAVATION AND METHOD OF TIMBERING DOUBLE TRACK SECTION NEAR MANHATTAN SHIELD CHAMBER (IN GOOD ROCK).

TABLE II.—WEIGHTS OF CAST-IRON AND CAST-STEEL LININGS AND STEEL BOLTS USED ON NORTH RIVER DIVISION OF THE P. R. R. TUNNELS INTO NEW YORK CITY.

Type of lining.	Weight of A—segment, lbs.	Weight of B—segment, lbs.	Weight of key, lbs.	Weight of one complete ring, lbs.	Diameter of bolts, ins.	Weight of 1 bolt, nut & 2 washers, lbs.	Weight of bolts, nuts, and washers per ring, lbs.	Total weight of one ring, segments & bolts, lbs.
Ordinary cast-iron with calking pockets	2,038	2,043	469	22,807	1¼	6.62	840.74	23,737.74
Ordinary cast-steel with calking pockets	2,220	2,225	510	24,940	1¼	6.62	840.74	25,780.74
Ordinary cast-iron without calking pockets	2,063	2,068	480	23,183	1¼	6.62	840.74	24,023.74
Ordinary cast-steel without calking pockets	2,247	2,252	522	25,249	1¼	6.62	840.74	26,089.74
Heavy cast-iron without calking pockets	2,579	2,584	606	28,985	1¾	10.5	1,333.50	30,318.60

FIG. 8. VIEW IN SOUTH END OF MANHATTAN SHIELD CHAMBER, MAY 29, 1905, SHOWING TIMBER ERECTOR FOR PLACING SEGMENTS OF ARCH.

The weights of the several types of lining are as per Table II.

A calking groove is taken out of the inside edge of each flange 9-32-in. in width and 1½ ins. in depth except as above described for "pocket iron." It is intended to calk these grooves with iron borings and sal-ammoniac to ensure a water-tight joint between each pair of plates. The rest of the surface of each joint is machined to a smooth surface. There is a hole in the middle of the skin of each segment tapped with 1½-in. standard pipe thread and closed by a screw plug. This hole is used for grouting through.

For going round curves either horizontal or vertical or to correct deviations from the theoretical line or level, tapered rings of two kinds, horizontal and vertical, are used. In the horizontal taper ring when the key is at the top, one side of the ring is 30½ to 31 ins. long as requirements necessitate at the horizontal axis, while the other side is the normal 30 ins. in length. The vertical taper rings are of two kinds, depressors and elevators, the former having its key, the other its bottom plate, 30½ to 31 ins. long. In the ordinary straight rings the A-plates are alike and interchangeable with each other; but in the taper rings each plate in a ring has its own place, and when the ring is erected care has to be taken in seeing that the plates are erected in their proper sequence.

The ordinary type of iron is used from the shield chambers until the tunnels are under the river bed, where the heavy type is used to make the structure approximate more closely in weight to the silt it displaces and thus eliminate anticipated difficulties due to suspected buoyant action in the quasi-fluid silt through which the tunnels are driven.

BORE-SEGMENTS.—The metal lining of these tunnels differs from any previous lining in the use of bore-segments. These bore-segments, fully shown in Fig. 9, have the object of permitting the subsequent sinking of the foundation columns. They are placed on the bottom center line, every 15 ft.; as the bore-segments occupy a length of two rings, the lining consists of four plain rings alternating with two bore-segment rings, in sequence. Each single one of the bore-segments is of the same over-all dimensions as an A-segment, which it replaces. While the make-up of the normal ring of lining is undisturbed in this respect, it is shifted circumferentially by the necessity of having the bore-segment and hence the key on the vertical axis; therefore the "breaking joint" of the longitudinal joints, which otherwise is strictly followed, is interrupted at each pair of bore-segment rings. The bore-segments are of cast-steel.

It will be seen that a pair of bore-segments when in place in the tunnel will allow if necessary a screw column of 4 ft. 8 ins. diameter over the blade with a shaft of 2 ft. 7 ins. external diameter being put down. In building the tunnel this 2 ft. 7 in. hole is closed by a cast-steel plug, which may form eventually the nose or bottom of the column. This plug is held in place against the upward pressure of the silt by two dogs, each held in place by a 1½-in. tap bolt in the circular flange of bore-segment No. 1. As an additional safeguard, the dogs themselves are held from moving at the ends which rest on the longitudinal flange of the A-segment on each side of the bore-segment by a dog-holder.

The opening in the plug is closed by a cast-iron plug cover; this is held down on the top of the plug by a steel yoke which engages in a circular flange formed in the inside of the plug. The yoke is attached to the cover by a 1¾-in. tap bolt, which passes through a 2-in. bored hole in the center of the cover. The plug cover is circular and 19¾ ins. in diameter and sits on a corresponding seating bored and faced in the plug. A ¼-in. rubber packing ½-in. wide makes the joint tight. Eccentrically on the plug cover is a hole tapped and fitted with a standard 3-in. pipe plug for the purpose of making any exploratory borings it may be decided to take at any pair of bore-segments. A lug with a 1-in. hole is also provided on top of the cover for lifting.

In order to give room for the blade of a screw column foundation, there is a slot cast under the under portion of the circumferential flange of

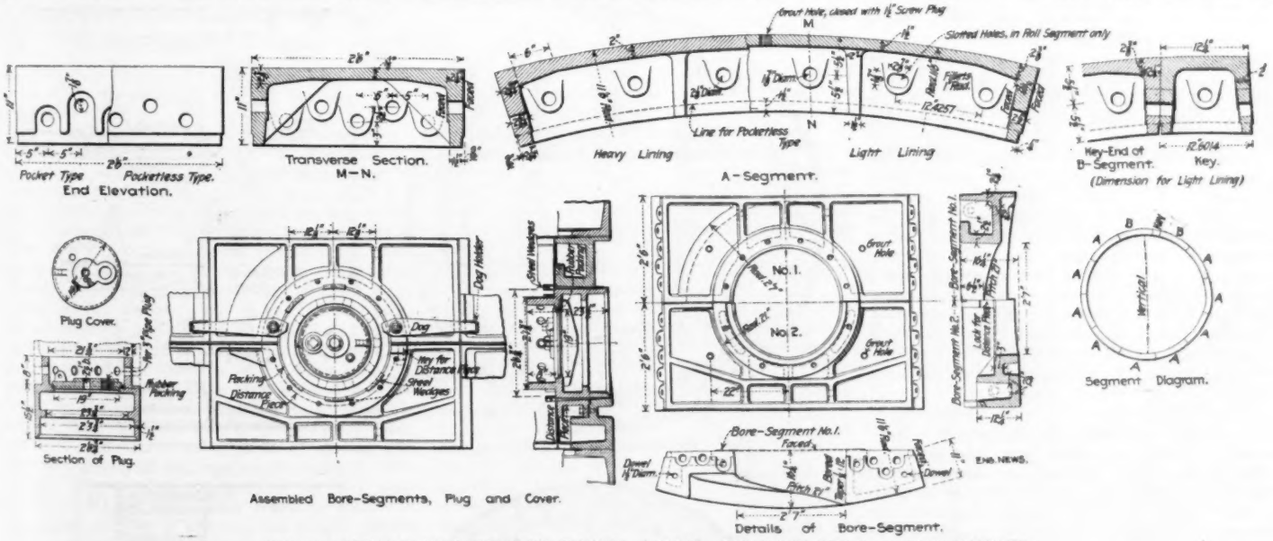


FIG. 9. DETAILS OF CAST-IRON TUNNEL LINING, AND CAST-STEEL BORE-SEGMENTS.

Cast-steel segments of the same form and dimensions as the "ordinary" or "light" cast-iron A and B-segments were used in the transition from rock to river silt, Manhattan end, and under the Manhattan bulkhead or seawall.

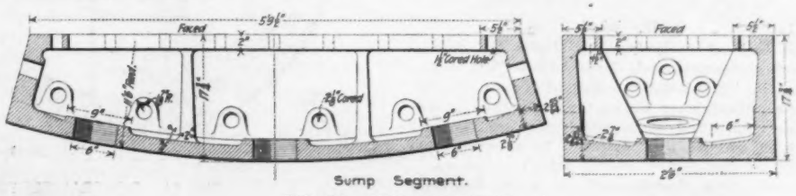


FIG. 9A. SUMP SEGMENT.

bore-segment No. 1, while on bore-segment No. 2 is a recessed surface. In segment No. 2 there is a distance piece and key of cast-steel which covers the slot and gives a symmetrical finish around the bore in conjunction with the flange of bore-segment No. 1 and simplifies the finish between bore and column; this forms a removable flange, making the circular flange round the screw pile opening. This distance piece and key can be removed while the screw blade of a column is being put in, and remain off until the blade has been turned sufficiently to clear bore-segment No. 2, and are then replaced.

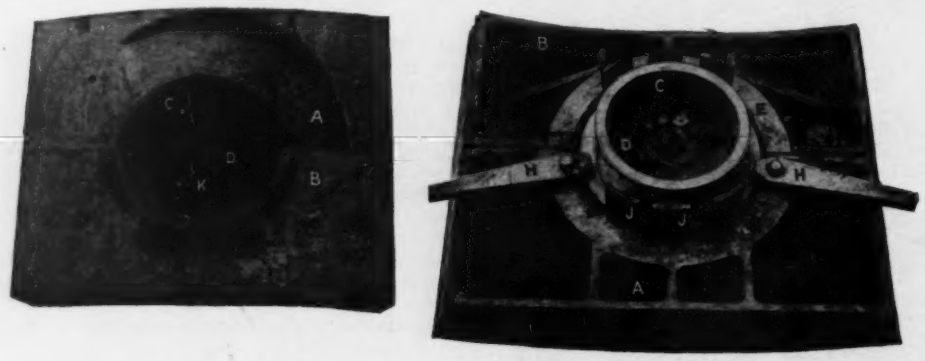


FIG. 10. TOP AND BOTTOM VIEWS OF ASSEMBLED BORE-SEGMENTS.
A, bore-segment No. 1; B, bore-segment No. 2; C, plug; D, plug-cover; E, distance-piece; F, key; H, dog; J, steel wedges; K, yoke.

A tight joint is made between the circular opening for the column or bore and the plug—during the construction of the tunnel—by driving wooden wedges tightly in all around. It is found that to maintain a tight joint it is necessary to drive the wedges to the splitting point. In Fig. 10 are shown top and bottom views of a completely assembled bore-section, comprising two segments, the plug, cover, dogs, etc., which should make the construction clear.

The use of these bore-segments, or rather the intention to use foundation columns, has led to the adoption of a special type of ring for use on special occasions. This type is known as the slotted-hole ring, and its use is as follows: It is found that tunnels lined with metal and driven by shield have a tendency to turn during construction on their central axis or roll, as it is usually termed, and as it is desirable to keep the foundation columns central to the tunnel, it is necessary to prevent this roll. It is for this purpose that the slotted-hole rings are used. They are identical with the other types of lining except that the bolt holes in the circumferential flanges are longer circumferentially than radially to the lining. In this way the roll can be corrected whenever it increases beyond a limit allowed.

At the lowest point of the grade, three special sump segments are built into the bottom of each tunnel to receive any water from percolation or condensation. The design of this segment is given in Fig. 9a. The segment is built in the tunnel at the invert just as an ordinary A-segment. When it is desired to form the sump the bolts attaching it to the adjacent plates will be withdrawn and the plate forced down into the silt, castings rectangular in plan will be attached to its top flange as the sump segment descends until the sump is sufficiently deep, when attachment will be made to the tunnel by special castings. Should the resistance to its downward movement prove too great, one or more of the three 6-in. holes in the skin of the plate may be opened and the silt allowed to flow in. A concrete lining will be placed in each sump inside its iron lining.

The Shield.

The task of designing the shield for driving the sub-aqueous tunnels devolved upon the writer, under the immediate direction of Mr. Charles M. Jacobs. Experience shows that tunneling operations in soft and water-bearing ground depend for both success and economy to a remarkable extent on the design of the shield. Most careful study was therefore given to the problem, and the more so as difficult work was to be accomplished, involving different kinds of soil (quicksand and gravel, loose earth and rock) and the transition from one to another, with the additional complication of large obstructions, as pile piers, riprap, etc. It is gratifying to be able to report that the shield as designed has proven completely successful in each one of the four headings, so much so that while one or two minor details can be improved all of the leading features of the shields would be retained if a new design were to be made for the same work on the basis of the experience in driving this tunnel. The design of the shield was chiefly governed by the nature of the ground other than the Hudson silt which had to be passed through, namely, the combination of rock and silt, rock and sand, full face sand and gravel, and the artificial obstructions, when, during the course of the work, it was necessary to keep an open or timbered face for removal of same. Much thought was given to the consideration of the best means compatible with reasonable progress for accomplishing the safe excavation of ground under these conditions. Mechanical face appliances which may be said to be absolutely safe were designed and considered, but were discarded as impracticable from the point of view of reasonably rapid execution of the work, and especially as other and simpler means could be devised for protection, not only of the men employed in the shield, but of the tunnel already constructed—chiefly, simple-operating doors and a water trap or bird fountain to be referred to hereafter. It was considered highly advisable to have easy access, and therefore easy egress to and from the face, for men in emergency, with suitable provision for the shield's "choking itself" with inflowing sand or silt should the men lose control at the face. It was also considered inadvisable to hinder the progress of the work by ingenious devices, which, as stated above, were discarded.

Some of the leading features are new to shield-design in America, and one of them, the style of door used, is original in this shield. Instead of slats, ordinary hinged, horizontal or vertical sliding, or rotary doors, it was decided to adopt a segmental gate pivoted on an axis parallel to the face of the shield bulkhead. A door of this type is balanced as respects external pressure in all positions, is simple to operate and reduces the chances of jamming in emergency to a minimum. The other important elements of the shield are: Sliding platforms, moved by rams independent of the shoving rams; a removable hood extension on the upper three-quarter circle of the cutting edge; exceptionally heavy construction; and maximum simplicity in piping and other operative arrangements. The shield

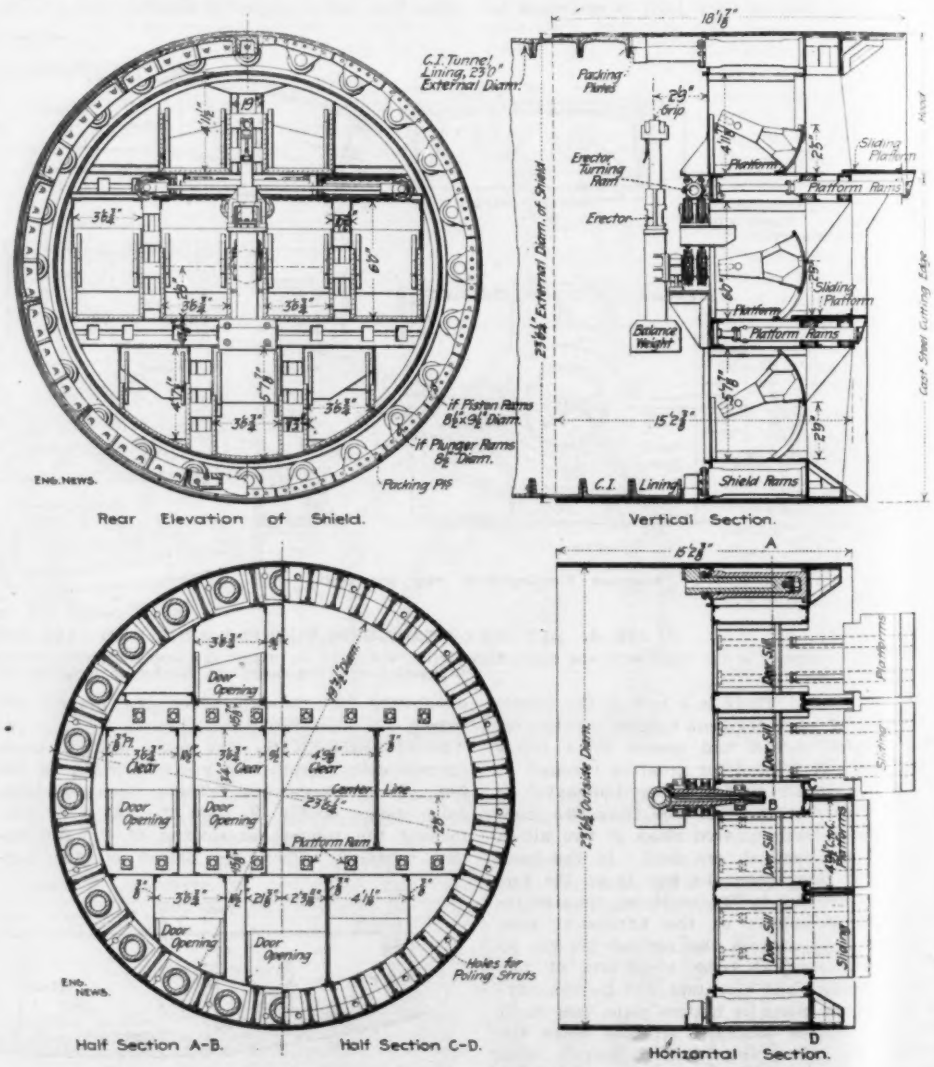


FIG. 11. GENERAL ELEVATIONS AND SECTIONS OF SHIELD.

has only one transverse bulkhead, no air-locks or other provisions for maintaining higher face-pressure, and no material chutes or any passage other than the nine openings with pivoted doors. The nine working pockets are roomy, though the bulkhead is placed very close to the cutting edge. The cutting edge was built forward 25 ft. by means of the sectional removable hood.

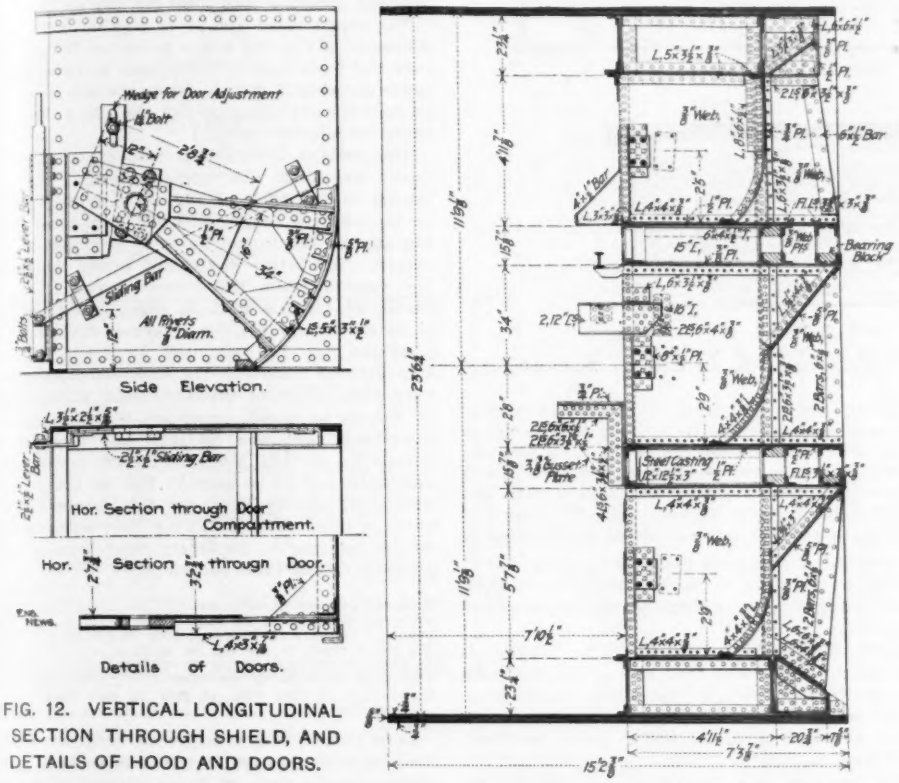


FIG. 12. VERTICAL LONGITUDINAL SECTION THROUGH SHIELD, AND DETAILS OF HOOD AND DOORS.

The hood was used up to a short distance beyond the shore lines prior to work in the silt under the river.

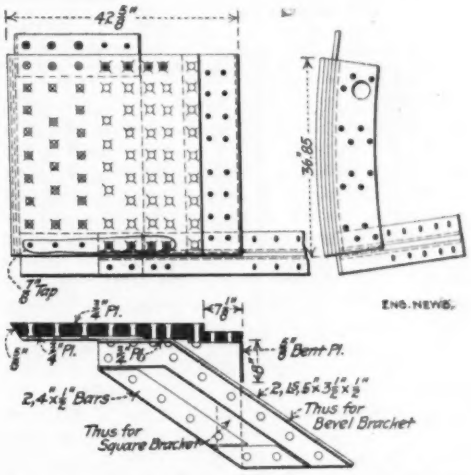
The drawings Figs. 11, 12 and 13 give representative views of the shield. The diameter of the shield was fixed as follows: The external diameter of the cast-iron tunnel lining is 23 ft.; the internal diameter of the skin of the shield which encircles the tunnel lining has been made 2 ins. greater to give sufficient room for the erection of the cast-iron lining within. This skin or tail of the shield is made up of three steel plates, 3/4-in., 5/8-in. and 3/4-in., respectively, making a total thickness of 2 1/8 ins., thus making the outside diameter of the shield 23 ft. 6 1/4 ins. The length of the shield is 15 ft. 11 7/16 ins., exclusive of the hood. The rear extension, skin or tail of the shield overlaps the lining a maximum of 6 ft. 4 1/2 ins. during ordinary working, and the minimum overlap is 2 ft. during the operation of taking any ram out for repairs. This overlap also permits of removal of any segmental plate of a ring which might be fractured during the process of shoving the shield against it, without exposing the dangerous ground. The joints of the skin of the shield are butt joints covered by the adjoining plates, and having no inside or outside cover-plates, being flush-riveted entirely outside and flush-riveted inside for the length of the tail. For the purpose of erecting the shield in the restricted space available underground, the annular frame of the shield is made up circumferentially in eight segmental pieces, and the bulkhead of the shield is arranged for building in suitable pieces underground. Apart from the junctions of the removable cutting edge or the hood with the main shell or shield there are purposely no circumferential joints in the skin outside, the plates extending the length of the shield proper.

The shield is, generally speaking, braced and stiffened as follows: Annular web-plates fore and aft of the ram chambers, connected by angles, and an inner skin of plate, form a ring-shaped frame 25 3/8 ins. thick radially and about 5 ft. long. Gusset plates on radial planes longitudinally between each two of the 24 rams securely brace this main ring. These gusset plates are continued in front of the ram chambers and form bevel brackets supporting the cast-steel cutting edge. Between these gusset plates, similar bevel brackets are placed centrally with each ram, forward of the ram chambers, to assist in taking the thrust.

The structural framing of the bulkhead of the shield has been as far as possible kept open in the rear to permit of running pipes within the boxing and to give accommodation for the installation of any fittings that might be found desirable to install at a future date without being obstructive to work. The four corner pockets were also left open rearward to permit of the installation, if desirable, of air-hydraulic pumps and water tanks (which, however, was not done). This interior structure further consists of two continuous floors or platforms, which form, in conjunction with three vertical partitions, the openings giving access to the face. Both floors of the shield and the rear halves of the vertical partitions extending through it are shaped as box-girders. The openings through the bulkhead may be partially or entirely closed by pivoted segmental doors, which may be raised or lowered without displacing any muck. There are nine such openings, the clear width of each being 2 ft. 7 ins., the height varying from 2 ft. 2 ins. to 3 ft. 4 ins., according to the location (see DOORS, below).

HOOD.—It was considered expedient to adopt the Dalrymple-Hay hood or roof extension of the shield at the face as means of more rapidly traversing the gravel, sand, etc., which had to be gone through before the river silt was reached. This hood was designed with a view to its being detachable and is made in complete segments to permit of easy erection or detachment underground. The hood projected 2 ft. 1 in. beyond the general plane of the cutting edge and extended down to the level of the top platform, and additional pieces were provided by which the hood might have been extended to the lower platform. The writer, however, believes, from experience on this work, with the hood in sand and gravel that it is preferable to have a hood extending down to below the bottom platform as originally designed. Trapezoidal steel castings formed the junction between the hood and the ordinary cutting edge.

The hood was formed in nine sections built up of two 3/4-in. and one 5/8-in. skin plates as in the shield itself and supported by interior longitudinal cover plates at the junction between each pair of sections, the cover plates in turn being supported by brackets attached to the forward ends of the driving ram chambers. Being detachable, the hood was attached by bolts and little difficulty was experienced in removing it when its use was over, and replacing it by the regular cast-steel cutting edge which was built in 24 sections and placed round the shield, each section being 30 27/32 ins. in circumferential length, 16 3/16 ins. in cross-section length and 2 1/8 ins. in thickness.



SLIDING PLATFORMS.—The floors or platforms, of which there are eight, may be extended 2 ft. 9 ins. in front of the shield or 8 ins.

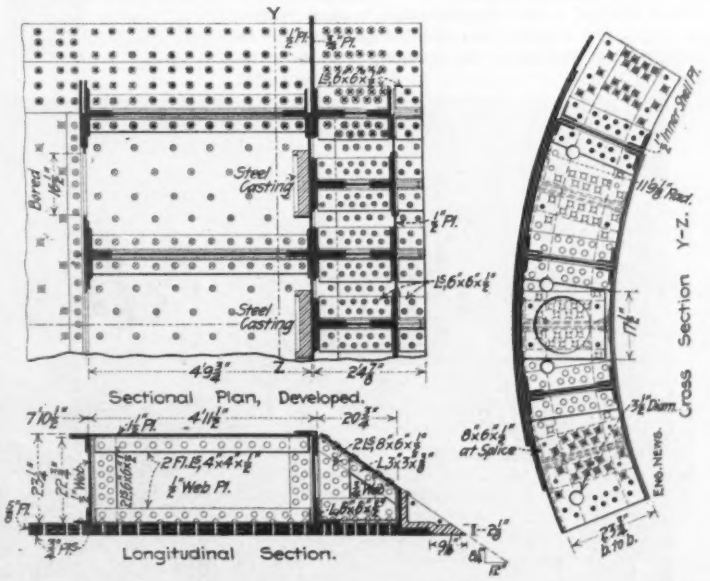


FIG. 13. CIRCUMFERENTIAL SECTION THROUGH SHIELD, DEVELOPED ON OUTER SKIN, SHOWING SHIELD RAM POCKET AND RIVETING OF OUTER SKIN.

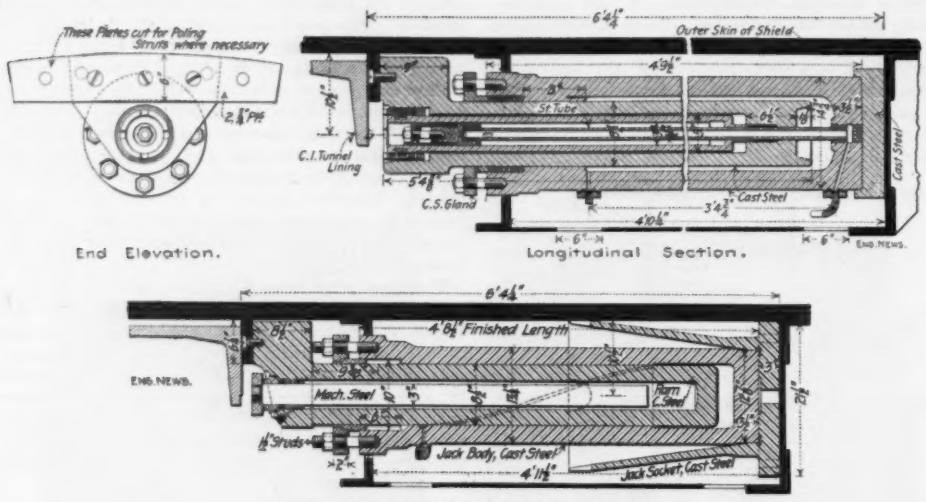


FIG. 14. DETAILS OF SHIELD RAMS.

Upper drawing: Ram designed by the railway company's engineers in advance of the contract.
Lower drawing: Ram actually used; designed and built by Watson-Stillman Co. for O'Rourke Engineering Construction Co., contractors.

ful for various purposes in all kinds of ground. One purpose of such an extension is its use as a cover or hood under which to work ahead of the shield. In rock they enable drilling and blasting to be carried on in three levels. In sand and gravel the sliding platforms not only act as shields or covers, but also as struts supporting the soldiers which in turn support the breast boards; with a view to this the platforms were provided with angles against which the soldiers are supported as hereinafter described.

The first hydraulic sliding platforms were conceived by the writer in 1894 and adopted in accordance with his design on the shield of the 23-ft. internal diameter tunnel of the Waterloo & City Ry., London, under the direction of the late Mr. J. H. Greathead, in 1895. Their first use in America was in the shield of the south tunnel of the New York & Jersey Railroad in 1903 (Old Hudson River Tunnel).

DOORS.—Much consideration was given to the design of the doors. Hinged doors, sliding doors, guillotine doors, revolving shutter doors, etc., were considered and thought wanting in some respect. The main consideration kept in view in the design of the doors was as follows: The desirability of quick and sure closing arrangements against a run of quicksand, mud or water, or both. The pivoted segmental door was held to fulfil this for the following reasons: It shuts without the necessity of having to displace material flowing into the tunnel, and whilst open it gives its own weight to assist in closing; it has a simple means of release from its open position. It was, therefore, decided to adopt the pivoted segmental door as being the most serviceable, and meeting fewer objections than any other device otherwise considered. The door is kept open by a catch of small bearing area which can be released by means of a simple lever arrangement from the back of the shield, and is arranged so that it can be kept in several stages partially, as well as wholly, open. The counterweight or unbalanced portion of the door, which assists the closing operation, weighs 800 lbs. For details of the doors, see Fig. 12. One advantage in doors of this sort when thus located is the possibility of having platforms of ample area behind the doors on which men may safely stand clear of any work overhead and the sweep of the erector.

BIRD FOUNTAIN OR WATER TRAP.—A bird fountain or water trap was provided at the rear of the bulkhead of the shield. Angle-irons bolted to the jambs of the openings to which plates of steel could be bolted were provided. This trap, though an obstruction to passage between the face and the tunnel, is sufficient to trap perfectly—with the assistance of compressed air—the water-bearing ground, should the face collapse and it be found impossible to close the doors in time to shut off the inflow of same. The openings to the face are so spacious that in an emergency the men could readily escape and get over this trap into safety. This shield trap originated in the design of the late Mr. Greathead in 1874, of a shield designed to construct a tunnel under the Thames at Woolwich. The shield was built and the shaft sunk, but the tunnel was never constructed.

OPERATING MACHINERY.—The machinery for operating the shield is entirely hydraulic and is designed for a maximum pressure of 5,000 lbs., a minimum pressure of 2,000 lbs. and a test pressure of 6,000 lbs. per sq. in. The average working pressure was 3,500 lbs. per sq. in.

The shield rams are 24 in number with a net diameter of 8½ ins. and a stroke of 38 ins. The ram and push-back actually used is shown by the lower drawing in Fig. 14, while the ram and push-back originally designed by the Chief Engineer is shown directly above.

The designs differ with respect to the pull-back, which in the original design was connected to the back of the main cylinder, while in the adopted design a special ram-head pressing against the tunnel lining is employed for the return. The latter wastes the return water into the tunnel, while the former drains it to the discharge tanks. In both cases the main ram is single-acting, 8½ ins. plunger diameter, the packings can be tightened up from the outside without removing the ram, which cannot be done with a ram of the differential plunger type. It should be noted, however, that the type of push-back used was designed and used by Mr. Jacobs in the old Hudson Tunnel south shield and continued to be used by him on the fourteen additional shields built for the construction of these works. The following are some leading figures relating to the shield rams with a water pressure of 5,000 lbs. per sq. in.:

	lbs.
Forward pressure of one ram	275,000
Forward pressure of 24 rams (all)	6,600,000
Forward pressure of 24 rams, tons (2,000 lbs.)	3,300
Equivalent pressure per sq. in. of face	105
Equivalent pressure per sq. ft. of face	15,200
Pull back pressure of one ram	26,400
Equivalent on full area of ram to pull back pressure	480

Some trouble was experienced with ram pistons bending, and perhaps it would have been worth while to make them of 10 ins. instead of 8½ ins. diameter. The single-acting ram was adopted in place of the double-acting type on account of its greater simplicity, repairs to rams being always a prominent factor in causing delays.

Each sliding platform, Fig. 11, is operated by two single-acting rams, 3½ ins. in diameter and 2 ft. 9 ins. stroke. The rams are attached to the rear face of the shield inside the box floors and the cylinders are movable and slide freely

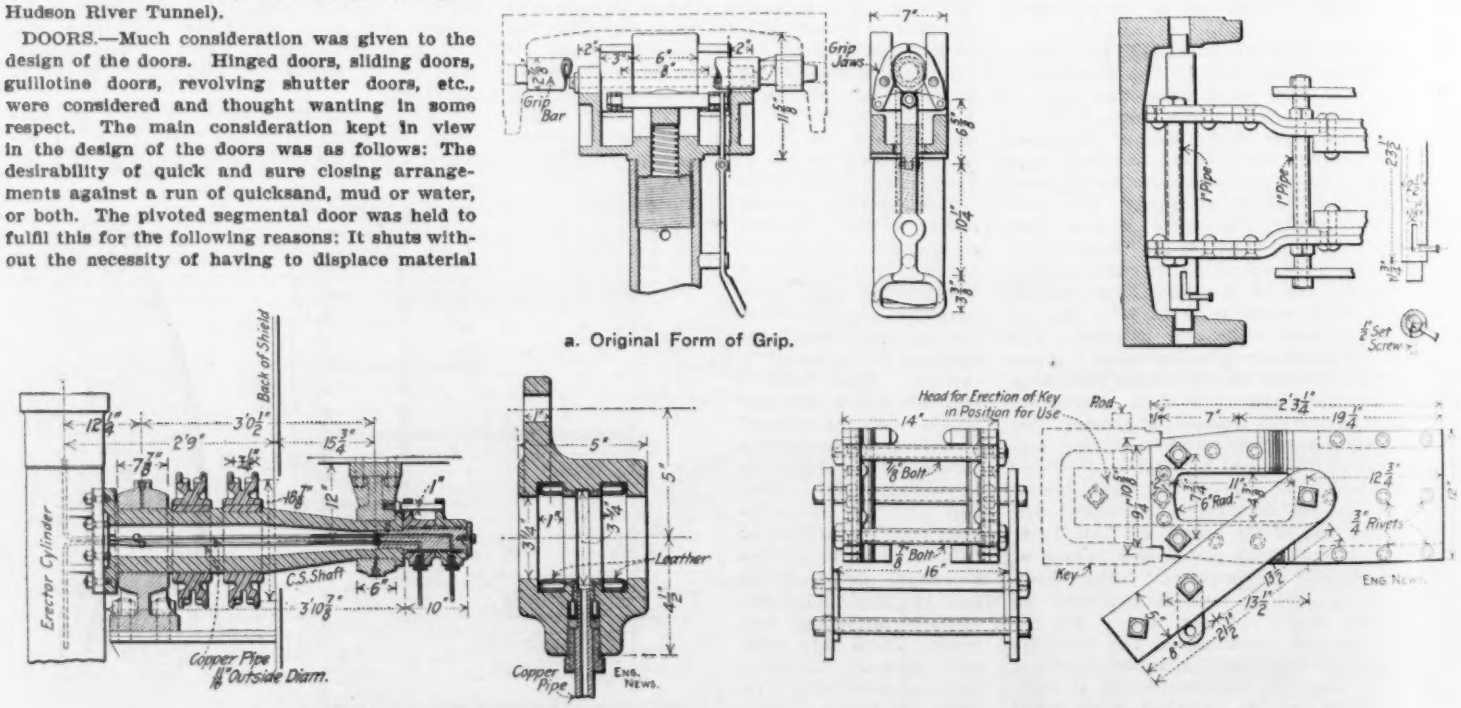
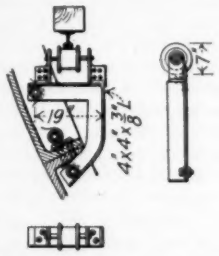


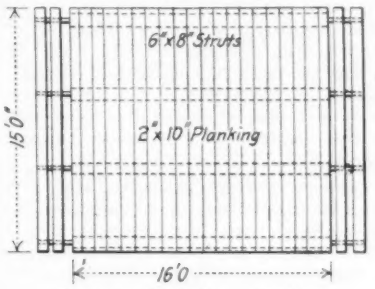
FIG. 15. DETAILS OF ERECTOR PIVOT AND TWO FORMS OF GRIP.

in bearings in the floor; the front ends of the cylinders are fixed to the front ends of the sliding platforms and covered with a steel nose or apron in front, which may be removed if necessary when working in silt. The cylinder thus supports the front end of the sliding platform and is designed to carry its half of the load on the platform. The following are some leading figures relating to the platform rams:

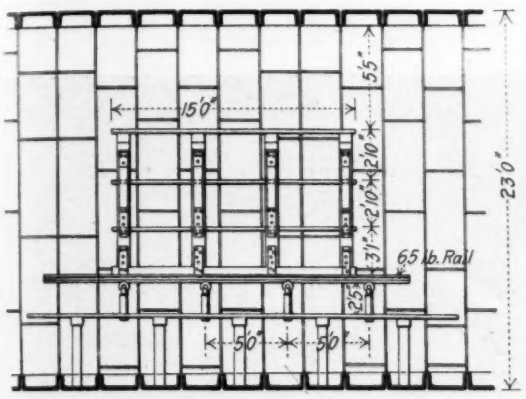
Forward pressure of each pair of rams (in each platform) at 5,000 lbs. per sq. in.	96,000 lbs.
Total area of nose of sliding platform	1,060 sq. ins.
Maximum reaction per sq. in. on nose	90 lbs. per sq. in.
Ditto per sq. ft.	13,040 lbs. per sq. ft.



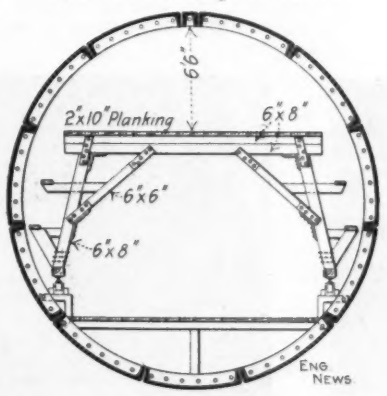
Details of Supporting Runners.



Plan of Bolting Platform.



Longitudinal Section.



Cross Section.

FIG. 16. MOVABLE BOLTING PLATFORM.

ERECTOR.—Before the shield was built a considerable discussion took place on the relative merits of one and two erectors on the shield. For two erectors it was urged that, since in passing through silt the erection of the iron took most time, two erectors would tend to reduce this time. Against this it was pointed out that the erector is one of the pieces of a shield which gives most trouble with breakdowns and that one erector would give less trouble than two. All the shields were finally built with one erector and this plan seems to have been justified by the result, as on several occasions 6 rings of iron have been put in in 8 hours. An advantage of the single central erector is that it works on a radial line and is therefore in a better position for handling segments (and especially key segments) into place than the double erector, which works eccentrically to the tunnel or shield, and only one operator is needed instead of two.

In several of the London (Eng.) tunnels two erectors have been successfully used, but under different conditions both as to the quality of labor and the nature of the ground.

The erector consists of a box-shaped frame, mounted on a central shaft, Fig. 15, which revolves in bearings attached to the shield. Inside of this frame there is a differential hydraulic plunger, 4 ins. and 3 ins. diameters, and 48 ins. stroke. To the plunger head are attached two channels which slide inside the box-frame, and to the projecting ends of which is attached the grip. At the opposite end of the box-frame is attached a counter-weight which balances about 700 lbs. of the tunnel segment at 11 ft. radius. and chain wheel keyed to the erector shaft. The

The erector is revolved by two single-acting rams fixed horizontally to the back of the shield, above the erector pivot, through double chains and chain wheels keyed to the erector shaft. The following table gives the principal figures concerning the erector:

	lbs.
Weight of heaviest tunnel segment	2,584
Weight of erector plunger and grip	616
Total weight to be handled by erector ram	3,200
Total pressure at 5,000 lbs. in erector ram, moving from center of shield	35,000
Total pressure at 5,000 lbs. in erector ram, moving towards center of shield	27,500
Weight at 11 ft. radius balanced by counterweight.	700
Maximum net weight at 11 ft. radius to be handled by turning rams	1,884
Total pressure of each rotating ram at 5,000 lbs. per sq. in.	30,000
Load at 11 ft. radius, equivalent to above	3,780

There have been two erector grips in use. The first (a, Fig. 15) was that originally designed to handle the lining segment without special lugs cast on. A bolt is passed through two opposite bolt holes in the circumferential flanges of the segment and held by a sliding collar locked by a spring catch. The grip-jaws close over the bolt and are self-locking. The total width of the erector grip is 7½ ins. less than the inside width of a tunnel segment, which may be slid in the grip to compensate for any deviation between the relative positions of the center line of the erector and the face of the finished tunnel lining. The direct thrust of the erector ram in placing a segment in position is taken by the fixed central part of the grip, projecting beyond the jaws, whether closed or open, and protecting the moving parts of grip from injury. The grip is designed to handle the key segment as well as the larger segments.

However, it so happened that the erection of the first shield was finished before the grip was received from the makers. Mr. P. Fitzgerald, the contractors' tunnel superintendent, therefore designed the grip shown at b in Fig. 15, which also picks up the plate by the same bolt or shaft passed through bolt holes in the segment lifted, but as will be seen is without springs or other mechanism. This design proved a success, and in fact so much superior in its simplicity and effectiveness to the original design that it was finally used on all the shields. The objection to the original grip was that its small width allowed the plate to hang nearer parallel than at right angles to the erector arm when being lifted, so that great pressure on the lifting bolt or shaft was necessary to get a B-plate into place, thereby bending the same, while in Mr. Fitzgerald's pattern the plate is always at right angles to the erector arm, and consequently there is no pressure on the bolt beyond the weight of the plate.

The original erector head was designed to handle both the key and other plates without change, whereas in the latter an auxiliary head has to be swung into position to handle a key.

The operating floor, from which shield, platform-rams and erectors are controlled, is placed above the erector rotating rams and forms a protection for the same; all the operating valves are located within easy reach of this platform.

The shield ram control is divided into four groups, the seven lower rams making one group, the five upper rams another, and the remaining rams on each side two more groups of six. Each group is controlled by one stop and release valve, but individual rams may be controlled by stop-cocks arranged in blocks, from which the pipes are carried to the rams; by these cocks the rams can ordinarily be cut out.

The sliding platform ram control is divided into two groups; those in the upper floor in one group, and those in the lower floor another. Each group is controlled by a stop and release valve, but individual platforms may be controlled by stop-cocks arranged in blocks from which the pipes are carried to the rams.

The movements of the erector ram are controlled by a two-spindle balanced stop and re-

FIG. 17. VIEW OF SHIELD FROM FRONT DURING ERECTION.
North tube, Manhattan, looking east. March 29, 1905.

taining valve operated by one hand-wheel, and the erector rotating rams are controlled by a similar valve with four spindles, also operated by a single hand-wheel. Both are located inside the top pockets and within easy reach from the operating platform.

The hydraulic pressure is brought through the tunnels by 2-in. hydraulic pipe, connection being made to the shield by flexible copper pipe.

WEIGHTS.—The following table gives the estimated weights of the complete shield with erector, as designed and exclusive of cast-steel cutting edge:

	lbs.
Structural steel	227,000
9 doors	8,000
Hood	14,000
24 shield rams at 3,735 lbs.	90,000
Erector	7,000
Erector turning rams and chains	5,000
Erector shaft and bearings	2,000
Sliding platforms and rams	33,000
Total weight	386,000
Net tons	193

With the addition of cast-steel cutting edge, cast-iron funnels to guide replaced rams and other minor additions the total weight of the shield was fully 200 tons.

The photographs Figs. 17, 18 and 19 are presented to give a more concrete idea of the shield.

AIR LOCKS AND OTHER PLANT IN TUNNELS.

The platforms, trackage, bulkheads and locks, etc., in the tunnel are perhaps next in importance to the shields in determining the economy and security in the work. Their design in this case involved no pronounced novelty, but may be worth a brief description so that the working methods will be better understood.

Two bulkhead walls, which form the rear closure of the pneumatic sections, are built in each end of each tunnel, one just ahead of the shield chamber, the other about 1,200 ft. ahead of the first. One of them is shown in the drawing Fig. 20. The walls are 10 ft. thick, and were built of 1:2½:5 Portland cement concrete, being furthermore grouted up with Portland cement under a pressure of about 100 lbs. per sq. in. to make them thoroughly air-tight.

Each wall has in it three locks: man, material and emergency. These are of the same general type, but of different dimensions, each being equipped with hand-valves so arranged as to be operated from either outer end or from within. The floors of the man and material locks are on a level with the working platform of the tunnel, which is about 3 ft. 6 ins. above the invert; the floor of the emergency lock is about 5 ft. above the horizontal axis of the tunnel. The locks are made of steel plates and shapes and iron fittings, riveted and bolted together, with gusset stays similar to those used in boilers, and are calked to withstand 50 lbs. per sq. in. working pressure. All doors are fitted with glass bull's-eyes and rubber gaskets.

The man lock is 11 ft. long and of elliptical cross-section, with a vertical diameter of 6 ft. and horizontal diameter of 5 ft. The material lock, Fig. 21, is 25 ft. long and of circular cross-section, 7 ft. in diameter. The emergency lock is 20 ft. long and of elliptical cross-section, with a vertical diameter of 4 ft. and a horizontal diameter of 3 ft.

A number of pipes, conduits, etc., also pass through the wall: Two 1½-in hydraulic; two 8-in. low-pressure air; one 2-in. gage; one 8-in. empty; one 6-in. empty; five 2-in. electric conduits; one 6-in. high-pressure air; one 5-in. drain or blow pipe; one 10-in. pipe 32 ft. long, for locking rails through; one 5-in. empty; one 5-in. safety valve; all of wrought iron. Some of the walls have more spare pipes through them, but this is the general arrangement.

WORKING AND BOLTING PLATFORMS.—From the first bulkhead to the working heading of the tunnel is constructed a working platform, installed in 5-ft. sections as the advance of the shield permits. The labor of installing this platform is done by the regular heading-gang, the material being cut to length before being sent to the tunnel; it is built of 6 × 6-in. × 16 ft. cross timbers, spaced 5 ft. apart, with 6 × 6-in. × 3-ft. center supports, and is floored with 2 × 10-in. × 5 ft. spruce plank.

A bolting platform, Fig. 16, supported on brackets fitted with rollers and attached by chains to the shield is advanced each time a ring is "shoved for." This platform enables the men to handily reach all parts of the seven leading rings for the purpose of tightening bolts, etc. The view Fig. 19 shows this platform in service.

All piping and wiring for supply, exhaust, power, lighting and communication is advanced as the shield work progresses.

AIR SUPPLY.—The low-pressure air supply is conveyed from Bulkhead No. 1 to within about 75 ft. from the heading in 10-in. spiral-riveted flanged galvanized pipe, fitted with valves near the bulkheads and with a "flap" at the outlet end, which would prevent the exhaust of air from the tunnel should the supply pipe break. The flap is a piece of plank hinged to a strip that is bolted to the flange of the end section of pipe.

The high-pressure air supply (90 to 1[illegible] lbs.) for the drills and the grouting machine is taken from the main passing through the bulkhead and along the side of the tunnel, by hose attached where required to valved branches built into the pipe.

LIGHT.—The tunnel is lighted by electricity, there being two rows of lamps, one in the crown and one at the south axial line. The lamps are 16-c. p., 240-volt, two-wire system, and are spaced 35 ft. apart in the crown and 12½ ft. apart on the axial line. In addition, five nests of 5 lamps each are used at the heading. Candles are supplied for miscellaneous and emergency uses. The sockets for electric globes are fitted to a wooden reflector which is coated with white enamel paint on the inside.

VENTILATION is obtained by the use of the locks and the 5-in. blow pipe; the latter also serves to drain the tunnel, the air pressure at the heading forcing the water to an open sump at the foot of the shaft. The pop safety valve is also used at times to aid in discharging foul air.

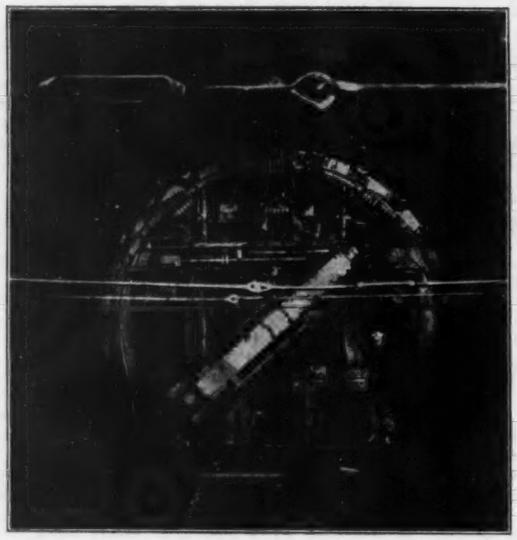


FIG. 18. VIEW OF BACK OF SHIELD IN WORKING ORDER.
South tube, Manhattan, looking west. Shield 130 ft. from shield-chamber, in rock. Oct. 3, 1905.

FIG. 19. LOOKING EAST TOWARD SHIELD IN WEEHAWKEN END OF NORTH TUBE. MOVABLE BOLTING PLATFORM IN FOREGROUND. MAY 8, 1906.

TELEPHONE.—A telephone at each shield communicates with the office at the shaft-head, and through this with the chief engineer's and contractors' offices, as well as with the general telephone network.

TRACKS AND CABLE HAULAGE.—Two lines of industrial railway tracks extending the full length of the tunnel on the working platform, with switches and sidings at the locks and heading, serve in transferring material and spoil. They, of course, converge into single-track in passing through the air-locks. At the shaft elevators they terminate in a steel-plate floor, to avoid switches.

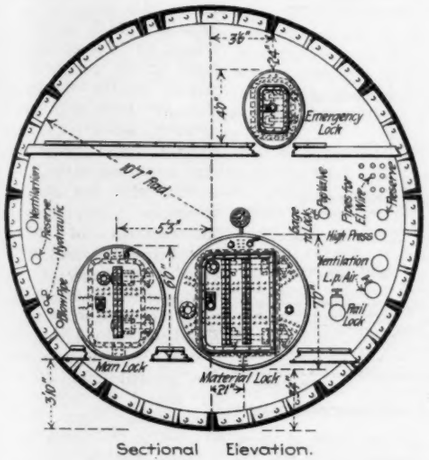
Between the locks of bulkheads Nos. 1 and 2 there is installed an electrically-driven cable haulage system for pulling the out-bound cars up grade. The cable is seldom used for balanced loads, its principal office being to haul loaded muck or empty flat cars up from No. 2 to No. 1 bulkhead. The general arrangement of this system was designed to haul an unbalanced load of twin muck cars spaced about 100 ft. apart up a grade of 1.3%. The cable operates over a distance of about 1,000 ft., the driving motor being located near No. 1 bulkhead, which is the highest point of the incline. The driving motor is a 25-HP. 220-volt series motor, running at 635 r. p. m. and equipped with a drum controller and resistance grids. The wire cable is ¾-in. in diameter and operates as an endless belt; it is arranged to travel on a number of guide sheaves which vary the elevations and directions to suit

the working conditions. The cable is kept taut by means of a 1,000-lb. weight attached to the "loop" sheaves at the end of the overhead loop.

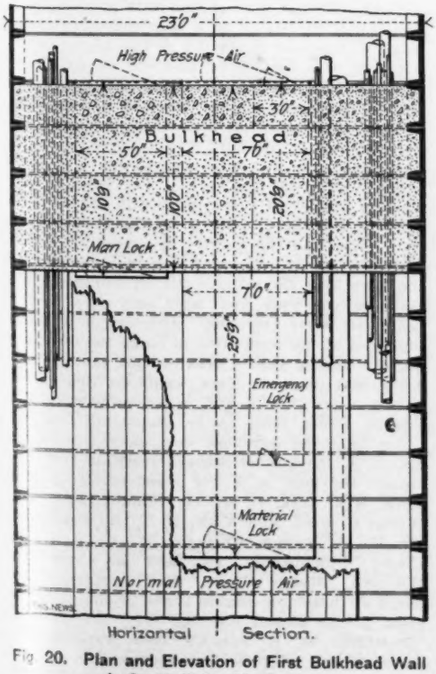
From bulkhead No. 1 to the shaft the cars are hauled up grade by a steam hauling engine at the foot of the shaft; at the Manhattan end there is one 10-HP. Lidgerwood engine for each tunnel, while at the Weehawken end one 25-HP. engine serves both tunnels, but the latter is supplemented by a 25-HP. electric winch in reserve.

PUMPS.—Drain pumps at the foot of either shaft lift the drainage water from a sump at the shaft to the surface. Three Cameron pumps, each of 250 gals. per min., are installed at the Manhattan shaft, with a 500-gal. Dean double pump in reserve for emergency use. At the Weehawken shaft the service drainage is done by a 500-gal. Worthington pump, with a 3,000-gal. pump of the same make in reserve for emergency. The Bergen Hill tunnels, extending over a mile westward on a continuous 1.30% grade, also drain into the Weehawken shaft, while at Manhattan the shaft receives little drainage other than that of the river tunnels, but is taken care of independently of this work.

GROUTING MACHINES.—For the purpose of injecting the cement grout, of 1 part of Portland cement to 1 part of sand by volume, used throughout the tunnel except where in the true silt, grouting machines made after the usual design (patented by Mr. J. H. Greathead in 1886), with the exception of the form of lid and the attachment of the engine, were used. They consist of a steel cylinder 36 ins. long by 22 ins. in diameter, having through its axis a spindle passing through a stuffing box at either end and driven by a small three-cylinder compressed-air engine. At the top of the cylinder is an opening closed by a flap lid shutting upwards against a corresponding flange furnished with a rubber seating. There is also at the top an air inlet ¾-in. in diameter, closed by a valve and to which can be attached a flexible hose connected with the high-pressure compressed-air pipe. At the bottom is another opening 2 ins. in diameter and also closed by a valve. To this opening is fitted a flexible hose ending in a nozzle which screws into the grout holes in the tunnel segments.



Sectional Elevation.



Horizontal Section.

Fig. 20. Plan and Elevation of First Bulkhead Wall in South Tube, Manhattan.

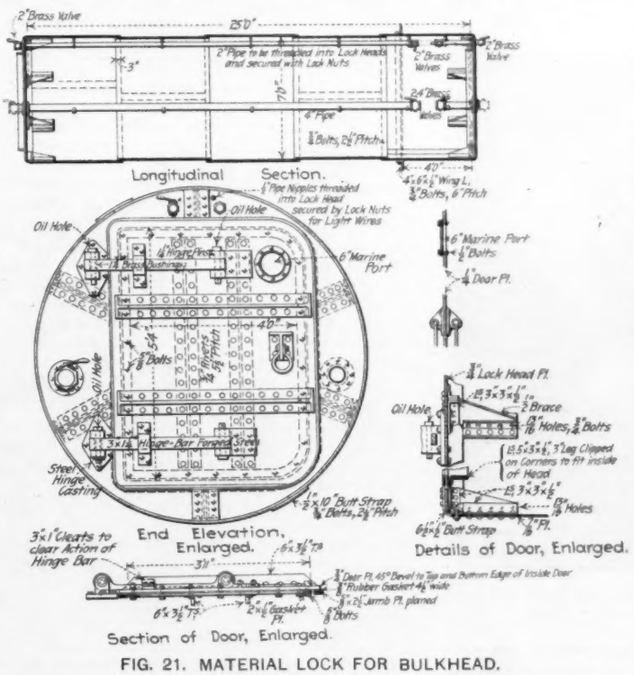


FIG. 21. MATERIAL LOCK FOR BULKHEAD.

The cylinder is partly filled with water and the sand and cement are introduced at the top opening; meanwhile the three-cylinder engine is turning the axial spindle which is furnished with blades or paddles 4 ins. wide by 8 ins. long. The operation continues until the mixture is of the consistency of thin cream. The lid is then pulled up against its seating and air at a pressure of from 90 to 100 lbs. per sq. in. is turned on through the top valve. The grouting nozzle attached to the lower 2-in. opening having been inserted in the hole in one of the segments, the grouting valve is opened and the compressed air in the cylinder forces the grout behind the tunnel lining, the movement of the paddles meanwhile keeping the mixture from setting. When the machine is empty the nozzle is withdrawn and the hole in the segment closed by a screw plug fitting threads tapped in the hole.

Beginning at a lower grout hole in the tunnel, grout is forced in till it reaches the hole above it, the lower hole is then plugged and the nozzle applied to the hole above, and so on until finally the highest hole is reached, and the whole tunnel is finally encased in grout filling every crevice between the outside of the lining and the ground as excavated.

POWER PLANT, SHOPS AND OTHER SURFACE PLANT.

At each end of the tunnel is a complete equipment for supply, handling and supervision, including everything from an air-compressor station and employees' locker-rooms to engineers' offices. A brief mention of this equipment will suffice, as with the exception of the compressor plant its details are not vital to the work here described. Moreover, the general arrangement of these surface plants was to a large extent determined by the fact that both terminal shafts lie in or alongside railroad yards, the Weehawken shaft being between the Erie R. R. freight tracks and the tracks of the New Jersey Junction Ry., giving track connection with the Erie, the Pennsylvania and the West Shore railroads, while the Manhattan shaft adjoins a freight yard of the New York Central & Hudson River R. R. and has a track connection with a small freight yard of the Pennsylvania R. R. at 37th St. At the Weehawken shaft sufficient ground space was available to house the entire plant in individual buildings, but at the Manhattan end the space was much more restricted, so that offices, boilers and engines, and shops, are grouped in a single building, a remodeled foundry building. The power plant (air, hydraulic and electric) is the same at both ends. The following items, given for one of the two plants, will therefore apply to the other.

Three 500-HP. Stirling boilers supply steam, at 150 lbs. pressure. A 54-in. × 100-ft. stack serves each boiler. Feed-water is supplied by three 13½-G Metropolitan injectors and two Blake duplex pumps, 10 × 10-in. stream and 6 × 10-in. water end. Two Worthington surface condensers, of 2,250 sq. ft. condensing surface each, take care of the exhaust from engines and compressors. Condensing water is pumped from the river through a 16-in. pipe line.

COMPRESSED AIR SUPPLY.—Compressed air for drills, grouting, etc., is supplied by a duplex Ingersoll-Sergeant compressor, with cross-compound steam end 14 & 26 × 36 ins. and simple water-jacketed air cylinders 13¼ × 36 ins. Its capacity, at 100 r. p. m., is 1,085 cu. ft. free air per min. The suction can also be connected to the discharge of the low-pressure compressors, thereby increasing this capacity. The maximum pressure is 130 lbs. per sq. in.

The air for the pneumatic working is supplied by three duplex Ingersoll-Sergeant compressors, steam end cross-compound 14 & 30 × 36 ins., air

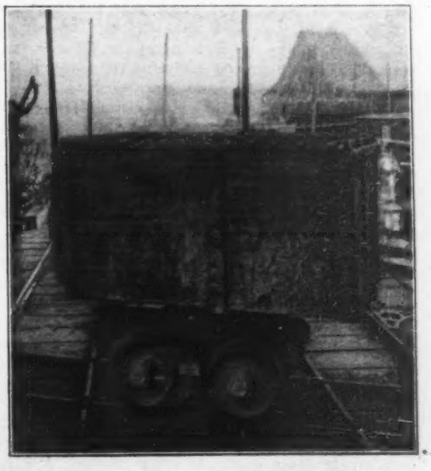


Fig. 22. Muck Car Used in River Tunnel.
Dimensions of Body: 2 ft. 6 ins. deep, 3 ft. 4 ins. wide, 4 ft. 6 ins. long. Capacity, 37.46 cu. ft. = 1.4 cu. yd.

cylinders simple duplex 22⅝ × 36 ins. The maximum capacity of the three is 12,000 cu. ft. free air per min., at 125 r. p. m., and a discharge pressure of 50 lbs. per sq. in. The speed is controlled by an automatic air-pressure regulator. The suction air is taken from the outside air, about 10 ft. above the roof of the engine-house, with the purpose of giving pure air to the tunnels.

Three aftercoolers, 32½ ins. × 11 ft. 4 ins., each having 809 sq. ft. cooling surface of tinned brass tubes, cool the low-pressure discharge to within 10° F. (guarantee figure) of the temperature of the cooling water. From the aftercoolers the air goes to three steel receivers, each 54 ins. × 12 ft., placed outside the engine-room, and fitted with

Fig. 23. Interior View of Hospital Lock for Engineering Staff, Manhattan Shaft.

weighted safety-valves. The receivers are connected to two 10-in. mains, of which one serves the south tunnel, the other the north tunnel; these mains continue through the bulkheads as already described (Fig. 20).

A fourth receiver, of the same size as the three low-pressure, but built for 225 lbs. test pressure, takes the discharge of the high-pressure compressor. A 4-in. steel pipe (standard) leads from this receiver to the tunnels. There are two by-passes between the high-pressure main and the two low-pressure mains, whereby high-pressure air can be expanded into the tunnel headings in case of an emergency.

PRESSURE WATER SUPPLY.—The high-pressure water required for the shield is furnished by three Blake direct-acting duplex pumps with outside-packed plungers. The steam end is 16 × 18 ins., the water end 2¹⁵/₁₆ × 18 ins. At 55 r. p. m., pumping against 5,000 lbs. per sq. in., the capacity of each pump is 57 gals. per min. Two of them are sufficient for running the shields (two shields), and the third is held in reserve. A 2-in. double extra strong pipe leads from the pumps to each heading; these pipes are buried in a trench (between engine-room and shaft) to prevent freezing in cold weather. At the pumps there are suitable connections and stop-valves to throw the discharge from any pump into either one of the two headings.

ELECTRIC SUPPLY.—Electric current for light and power is supplied by two 100-KW. 250-volt GE direct-current generators direct-connected to Ball & Wood high-speed engines running at 250 r. p. m. The switchboard has two machine panels and two distributing panels, and one panel carrying a circuit-breaker for the traction circuit.

HANDLING PLANT.—Each shaft contains two elevators, fitted with Lidgerwood safety platform cages driven by a double-cable reversible single-drum steam hoisting engine. A gantry frame is built over the shaft, and on the platform over this frame are narrow-gage (24-in.) tracks extending from the elevators to the muck-chutes and to points where lining segments can be conveniently loaded on the cars. The elevators are arranged to stop at both the ground and the gantry-platform levels. At the Weehawken shaft there is also an extensive system of narrow-gage tracks on the surface, and both surface and elevated tracks are operated by two Baldwin electric locomotives, with overhead trolley. At the Manhattan shaft (Fig. 24) the distances are short and the muck-cars and segment cars are moved by hand. The rolling stock at each end comprises about 75 flat cars for moving tunnel segments (capacity 3 tons each) and about 50 muck cars (1¼ cu. yds. each, Fig. 22). The combination of railway sidings, narrow-gage

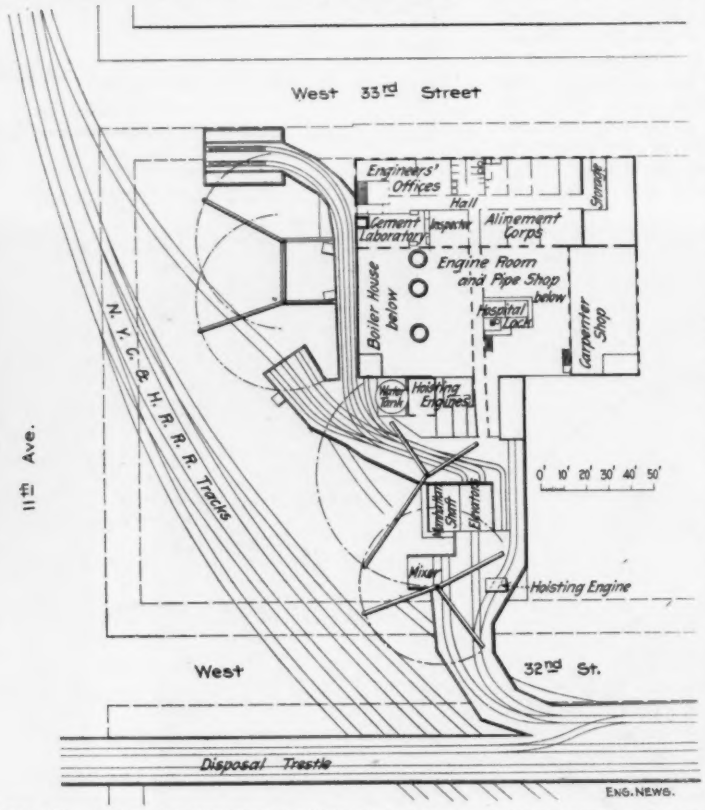


FIG. 24. PLAN OF SECOND FLOOR OF PLANT AT MANHATTAN SHAFT.

tracks, and shaft elevators, is supplemented by several derricks, both steam and electric, distributed in the yard and on the gantry platform, the total making a very complete handling plant. A further essential item in this plant is a material-disposal trestle, running from the gantry platform at the shaft to the river, and extending out along a pier, from where muck is dumped into scows.

EMPLOYEES' QUARTERS.—Locker rooms, fitted with steel-mesh lockers, steam drying-pipes, hot and cold shower and plunge baths, and coffee urns are provided at both ends. In connection with each is a hospital lock, for treating under pressure persons affected by the air pressure. The lock is double (see Fig. 23), so that the patient remains under pressure while the doctor passes in and out; the lock is housed in, and the enclosing space is heated by steam pipes. The coffee urns supply coffee to the men free of charge at all hours, and a supply of coffee is sent down to the men in the tunnels once during each shift. The offices of the engineering staff at each shaft are equipped with similar conveniences.

DRY CONCRETE filling for street railway track has been used at Indianapolis under special conditions. When a part of Northwestern Ave. was improved the traction company did not wish to lay new rails or to incur the expense of putting standard concrete foundations under the old rails. The track was therefore ballasted with a bed of concrete composed of 1 part natural cement, 2½ sand and 5 gravel, the only water being that contained in the sand and gravel. The mixing was done at the pits, and the concrete was filled in to a depth of 6 ins. under the ties. This filling was cheap and became very hard.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.

The second annual meeting of the American Society of Refrigerating Engineers was held December 3 and 4 at the House of the American Society of Mechanical Engineers, 12 West 31st St., New York City. The meeting was called to order shortly after 9.30 Tuesday morning, December 3, with an attendance of 29. Later, however, other members came, and before the meeting was over a fair proportion of the total membership of 146 were present. Four sessions in all were held; included among these was one evening session. A subscription banquet was given Tuesday evening, and a number of the members accepted invitations extended by the Goldschmidt Thermit Co., 43 Exchange Pl., New York City, to witness their process of welding iron and steel pipes, and by the De La Vergne Machine Co., Locust Ave. and 138th St., New York City, to visit their works.

Since the first meeting* of the Society, held last year, 28 new members have been added, and the report of the Finance Committee shows a balance of $271.75 on hand. Owing to lack of funds, none of the papers presented at the meetings thus far held have been printed separately, although those presented last year are given, together with the discussions on them, in the Transactions of 1905, now being delivered. The cost of this copy of the Transactions to members is $5 per volume; to non-members, $10 per volume.

Two amendments to the constitution offered by Mr. J. S. Louis, of Cincinnati, Ohio, were passed. One of these referred to the fixing of a definite date for the annual meeting in conformity with the laws of the State of New York, and the other related to a rearrangement of the order of business conducted at the annual meetings. It was decided to hold the annual meetings in New York City, commencing on the Monday preceding the first Tuesday in December.

Under the head of unfinished business, the proposed test of the York Mfg. Co.'s refrigerating plant at York, Pa., was brought up. An invitation was given the society last year by Mr. Thomas Shipley of said company to conduct this test, but according to Mr. J. E. Starr, New York, N. Y., who had this matter in charge, no action had been taken because it was inconvenient for the York Mfg. Co. to have the experiments made early in the year and later only two of the committee were available. Although it was the intention of the committee to make the test during the coming year it was learned that the experimental plant at York would be dismantled within a few weeks and in all probability the scheme would have to be abandoned.

The following members were elected to office: Mr. D. S. Jacobus, of Stevens Institute of Technology, Hoboken, N. J., for president; Mr. James Wills, New York, N. Y., for vice-president; Mr. Walter C. Reid, New York, N. Y., for treasurer; Mr. F. W. Pilsbry, Chicago, Ill., Mr. J. J. De Kinder, Philadelphia, Pa., and Mr. Llewellyn Williams, Boston, Mass., for directors. The terms of these new officers began at the adjournment of the second meeting.

President W. E. Parsons, New York, N. Y., stated in his address that whereas the society

*See Engineering News, December 14, 1905; p. 619.

had started as a national organization it had already become international in its scope. In the total membership of 146, 18 states are represented, and also many foreign countries.

At the conclusion of his address, President Parsons read his paper entitled, "A Future for the Ice Manufacturing Industry." In the latter he stated that in the refrigerating industry few men could be found suitable for this work that were ready made; they had to be made to order. He pointed out that the master of the situation was that man who could produce ice at the lowest cost, and that the cost of steam rather than that of fuel should be the chief point considered.

In the discussion which followed, it was pointed out that it cost less under ordinary storage conditions to maintain a sufficient temperature to prevent ice from melting than to make up this deficiency—that whereas it required 2 tons of refrigeration to make 1 ton of ice it required only 1 ton of refrigeration to maintain 1 ton of ice. In comparing costs in the two cases the cost of transportation in and out of storage must be taken into consideration. A case was cited in which natural ice was stored from the time of housing in winter till the following October with a loss of less than 8%.

The next paper presented was entitled, "The Allen Dense Air Machine," and was read by its author, Mr. H. B. Roelker, New York, N. Y. This machine is made only in small sizes—from ½ to 3 tons capacity and is used chiefly on naval vessels. It is well adapted for this purpose on account of using no chemicals which might be released by a shot in time of war. It is operated by steam and is classed as an auxiliary engine, entirely automatic in regulation. On 32 lbs. steam pressure a 2-ton machine of this kind requires about 25 HP.

Next on the program was a paper by Mr. Edgar Penny, Newburgh, N. Y., on "Experiments on Binary Refrigeration." The experiments described were made by means of an ordinary 10-ton refrigerating apparatus and the results obtained were presented to the society as an exposure of the binary refrigerating theory. Efficiency tests of the apparatus were made using ammonia gas alone, sulphur dioxide alone, the binary compound CO_2 and SO_2, and other compounds. Mr. Penny's conclusions, drawn from the results obtained, were, that any combination of gases in refrigerating machines will not give any better results than can be secured from any one of the gases alone.

In answer to a question raised in the discussion of the paper, one of the members said that with a compound composed of carbon dioxide and carbon disulphide he had obtained a lower temperature than with carbon disulphide alone, but that with the former the horse-power required in the compressor was more than enough to offset the lower temperature obtained. His results, he said, substantiated Mr. Penny's conclusions.

The fifth paper was entitled "Description of a Cold Storage Plant Utilizing Exhaust Steam," by Henry Torrance, Jr., New York, N. Y. The plant described was that of the L. C. Bates Co., at New Haven, Conn. The space cooled was 140,000 cu. ft. The cooling was formerly done with a 15-ton plant using direct steam at a consumption of 1.8 tons of coal per day. A new 50-ton plant using exhaust steam cooled the same space with a consumption of only 0.83 ton of coal per day.

"Refrigeration of Butter and Cheese," by Mr. C. E. Gray, of the U. S. Department of Agriculture, was next presented. Mr. Gray stated that very few butter rooms were held at a temperature above zero whereas many of them were held at 10° below zero. He said there was a considerable field in creameries for refrigerating machines of 10 tons capacity or less, and suggested the development of a simple, cheap, and efficient refrigerating machine that could be used by every dairy farmer. There was no discussion of this paper.

Mr. G. T. Voorhees, New York, N. Y., next read a paper on "Multiple Effect Compressors." He stated that the power required to do a fixed amount of refrigeration with multiple effect compressors was considerably less than would be required by a single large ordinary compressor doing all the refrigeration at the low back pressure, or than would be required by two ordinary compressors doing the refrigeration at two back pressures.

Next in order was a paper entitled "Vegetable Insulation" by Junius H. Stone. Mr. Stone stated that the principal points to be considered in the different forms of insulation used in refrigeration work were the ability to resist moisture and the freedom from capillary action, although the first cost, durability, efficiency, and cost of repairs were also matters not to be overlooked. He divided the various kinds of insulation into three classes: animal, mineral, and vegetable. Belonging to the first class are the hair and wool felts in use; these are cheap in cost but readily take up moisture. In the second class is enamel or rock wool, which is used both in loose form and in blocks. It possesses little structural strength but forms a good damp proofing material. Among vegetable insulations are paper, lumber and cork. The principal objection to these is the fire risk. Cork blocks, according to Mr. Stone, form the best insulation; they are free from capillary action and do not absorb moisture. Mr. Stone strongly advised coating exterior walls with damp proofing material, as the outer wall seemed to him to be the place where the first stand should be made.

Mr. R. L. Shipman, Ithaca, N. Y., was next in order with a paper on "The Water Jacketing of Ammonia Compressors." Although this paper was not presented in full at the meeting, Mr. Shipman showed from tests conducted at the York Mfg. Co. that water jacketing in a large majority of cases is not worth while. Nine-tenths of those using compressors, he said, think it impossible to operate them without water jackets, and nine-tenths of the water jackets used are worthless.

"Engineers' Specifications vs. Contractors' Warranty" was the title of the following paper. This was delivered by Mr. John C. Wait, New York, N. Y. Mr. Wait claimed that a warranty warrants a consideration unless it forms part of the contract, in which case the price of the machine contracted for is the consideration. He distinguished between guarantee and warranty, saying that the former is used in the sense of a man going security for another man's debt, whereas the latter is not assumed except for an extra price and thus becomes a burden to the purchaser. A warranty on a machine goes only to the purchaser—not to the party to whom the machine may afterward be resold.

The paper on "Thermometry and Temperature Regulation" by Mr. Harry Y. Norwood, was illustrated with lantern slides. The different processes in the making of various kinds of thermometers were clearly shown and described, and the calibration of them was also explained.

Mr. Thomas Shipley, York, Pa., read a paper on "Horse-Power per Ton of Refrigeration." He confined his remarks to compression machines and showed that in general from 25 to 36 lbs. of ammonia gas were used per ton of refrigeration. He said that clearance had some effect upon the horse-power per ton of refrigeration, but he could not state how much. The following figures were given, showing the difference in the power required with wet compression and with dry compression:

	Wet compression.	Dry compression.
Compressor I. HP.	2.066	1.603
Engine I. HP.	2.368	1.766

The next paper on the program was read by Mr. B. Franklin Hart, Jr., New York, N. Y., and was entitled "Data on Water Cooling Towers." Mr. Hart favored self-acting or fanless towers. The efficiency of water cooling towers, he said, depends chiefly upon their vapor carrying capacity, and this in fan towers is less than in fanless towers, because the air forced in soon becomes laden with vapor and can carry no more, whereas, in self-acting, open towers, air strikes the water from top to bottom at the same time and is not in consequence overburdened. He found by experimenting that after water reaches a temperature of 85°, the efficiency of a tower decreases very materially.

The fourteenth and last paper was "Oily Waters and Their Treatments," by Mr. Albert A. Cary, New York, N. Y. This paper dealt chiefly with oily waters in steam plants rather than in refrigerating plants. Mr. Cary first described the following methods of removing oil from steam: By filtration; steam washers; precipitation by gravity; oil catchers; precipitation of oil on surface of water; and by passing the steam through an oily material acting as an absorber. He then discussed the following methods of removing oil from feed water: Skimming the feed water; filtration; the use of chemicals and coagulants, and oil absorbents. He favored the last method in which the material used is obtained from a natural rock deposit and which is now being given a practical trial in one of the New York City power houses. The material being very light can readily be mixed with the water, and after absorbing the oil, is removed by filtration. Mr. Cary stated that the Waterside station in New York City, has been compelled to stop using their condensed water and to buy water from the city at the rate of 7½ cts. per 1,000 gals., chiefly on account of the impracticability of getting rid of the oil.

In the discussion which followed, Mr. D. S. Jacobus, Hoboken, N. J., asked if the trouble at the Waterside station was not due to the salt water with the oil rather than to the oil alone. In reply, Mr. Cary said that whereas the salt water might have something to do with it, the presence of the oil was the principal trouble.

The topical discussion then followed, that on the precautions necessary to safely test an old compression system with air, and that on concrete construction for ice tanks, etc., exciting the most interest. Some of the members favored the use of ammonia gas instead of air for testing old compression systems, and others favored cylinder oil. Mr. Thomas Shipley, however, claimed there was no danger in testing with compressed air. He said that the York Mfg. Co. had tested 1,000 machines by that means and had had no explosions.

Regarding concrete construction, Mr. J. E. Starr, New York, N. Y., said he knew of a reinforced concrete cold storage warehouse where the temperature ranged from 10° to 35° above zero and that during the 6 or 7 months the house had been in use, no cracks had developed except in the floor, which was made of 2½ ins. of concrete. These cracks, which developed soon after the floor was laid, were filled with cement containing a small proportion of chloride of calcium and had given no further trouble.

The construction of a concrete ice tank in successful use was described by Mr. J. S. Louis, Cincinnati, Ohio. This tank was built on an 8-in. cinder bed with a ½-in. cement finish. On this was laid 3-in. cork board, and then 5 ins. of concrete reinforced with ½-in. twisted steel bars placed 6 ins. between centers. These bottom bars were bent up at each end to enter the sides of the tank. The concrete was washed with dilute muriatic acid to cut off the finish. Its composition was as follows: Portland cement, 1 part; sand, 2½ parts; broken stone, 5 parts. This tank was installed four years ago and has given entire satisfaction; its cost was from 10 to 15% less than that of a steel tank of the same size.

A LARGE GERMAN STEAMER for the North German Lloyd Co. was launched Dec. 1 at Stettin, Germany. The new vessel has engines of 45,000 I. HP., and was christened "Kron Prinzessin Cecilie" by the Crown Princess. It is expected the vessel will be ready for service next August. This addition to the fleet of the North German Lloyd Co. will enable them to run a weekly service to New York of seven-day steamers. The "Kron Prinzessin Cecilie" was built by the Vulcan Shipbuilding Co., of Stettin, Germany.

THE OPERATION, EFFICIENCY AND CONSTRUCTION OF A MODERN PRODUCER GAS POWER PLANT.*

By J. R. Bibbins,† Jun. M. Am. Soc. M. E.

With all the present activity in power development for various purposes, industrial or otherwise, the value of the simple producer plant used exclusively for power generation, seems to have been somewhat overlooked or at least questioned. Gas producers, especially for bituminous fuels, are quite familiar in metallurgical work, notably in the various iron and steel industries; and although the problem of gas purification presented in power work is somewhat more serious, yet experience has indicated several fairly simple methods of solution. The ability of the modern gas engine to take the place of the steam engine in general power work has likewise been questioned, as well as the capacity of gas engine and producer to work together harmoniously under widely varying load demands.

Fortunately neither of these charges is founded on a basis of actual conclusive experience, and it is the purpose of this paper to present some practical data upon the operation of a thoroughly representative commercial gas power plant; one which is operating week in and week out, 24 hours per day, 6½ days per week, on a fluctuating manufacturing load, with a fuel consumption fully one-half that of a modern steam plant of like character and suited to the same work.

CHARACTER OF SERVICE.—The plant in question serves the entire Gould manufacturing properties at Depew, a suburb of Buffalo, N. Y. Two complete works are located here; one devoted to the manufacture of storage batteries and the other to the manufacture of railroad specialties, principally automatic couplers. The latter contains a large and well-equipped steel foundry. Both are electrically-driven and lighted throughout from the central power gas plant.

Contributing to the station load are a large number of labor-saving machines of different types, such as electric traveling cranes, charging tables, transfer locomotives, elevators, conveyors, fans, pumps and machine shop tools. The storage battery works also use considerable current at times for "forming" battery plates.

Assuming 50% loading factor, the average plant efficiency is 12%; as the efficiency of the engine is approximately 17% at this load the producer plant operates at an efficiency of slightly above 70%. With higher loading factor—75%, the plant efficiency is 13% average, engines 20%, and producers 65%. During an especially good day's run the efficiencies were as follows: Plant 15%, engines 21%, producers 71.5%. These results indicate that the producer plant is, from an everyday operative standpoint, fully as efficient as a high-grade boiler plant and frequently more so. It is certainly not more difficult to handle.

As to the cost of power, the following analysis reveals a total cost of well under 1 ct. per KW.-hr., including fixed as well as operating charges. At normal prices, coal costs $2.30 per ton. Assuming an average daily output of 5,000 to 10,000 KW.-hrs. representing the probable minimum and maximum for full working days, and adding the fixed or capital charges amounting to about 9% on $91,650 (or $81,000 excluding the battery), the distribution of cost items is substantially that given in the accompanying table.

APPROXIMATE POWER COSTS.

	Minimum.	Normal.	Maximum.
Output—KW.-hrs. per day.....	5,000	8,000	10,000
Fuel—Cts. per KW.-hr.....	0.25	0.22	0.20
Labor—Cts. per KW.-hr.....	0.28	0.17	0.14
*Supplies and repairs (estimated) cts. per KW.-hr.....	0.17	0.13	0.11
Operating costs—Cts. per KW.-hr	0.70	0.52	0.45
Fixed charges	0.45	0.28	0.22
Total costs—Cts. per KW.-hr..	1.15	0.80	0.67

*These charges are estimated owing to absence of more accurate data and the comparatively short time the plant has been in operation. Assume 25% of total power costs at 50% load factor, hence, the estimate is conservative.

GROUNDS AND BUILDINGS.—An excellent location has been chosen for the power plant adjacent to the Lackawanna R. R. main line. In the intervening space is a large semi-circular reservoir, serving the twofold purpose of a cooling pond and reservoir for general fire protection, and incidentally enhancing the attractiveness of the property to no small degree. See Fig. 1.

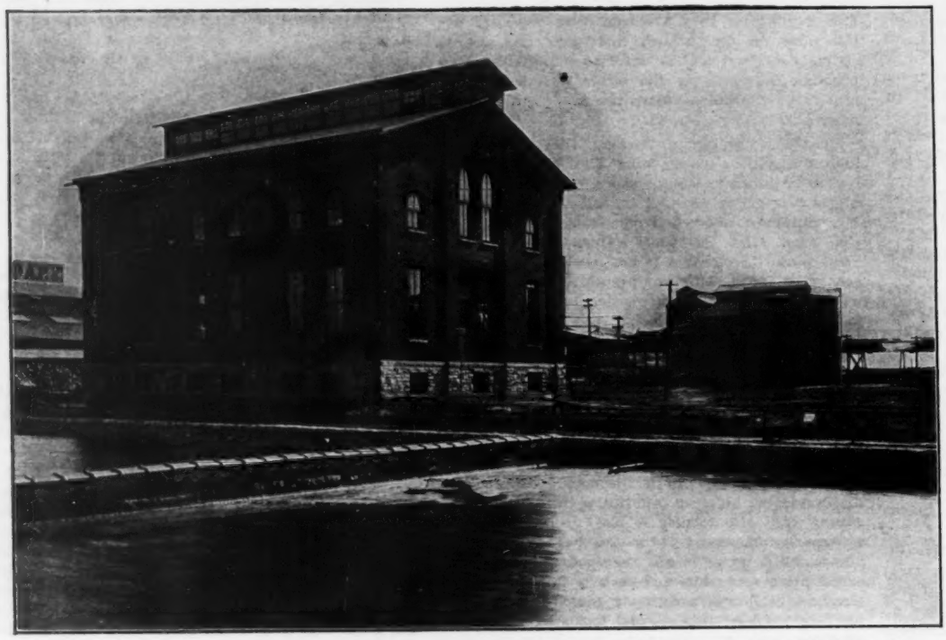


FIG. 1. THE GOULD POWER PROPERTIES AT DEPEW, N. Y., SHOWING THE COOLING POND IN FOREGROUND AND THE PRODUCER HOUSE IN BACKGROUND.

For convenience to coal supply the producer house is located several hundred feet in the rear, adjacent to a large metallurgical producer plant serving the steel furnaces. A single coal handling system thus serves both producer equipments. This arrangement of buildings emphasizes the possibilities in gas power work of separating, at any distance, the producer and gas engine parts of a power plant for operative, or other convenience.

Brick, steel and concrete are largely used as building material. In the producer house where the fire hazard is, of course, considerable, no wood at all is employed, walls and roof being constructed of corrugated iron and charging floor of boiler plate. Spacious monitors in both buildings provide the very necessary ventilation and light.

GENERATING PLANT.—The installation consists of three units of similar size and identical construction, as shown in Fig. 2. By the use of direct-connected units, the total floor area per KW. is 6.1 sq. ft.

The efficiency of the engines as heat engines is well indicated by the results of tests shown in Fig. 3. The upper concave curve represents the gas consumption per B. HP. under different loads, and the convex curve the kinetic or absolute efficiency. The engines were built by the Westinghouse Machine Co.

The engines operate on the four-stroke cycle involving constant quality of mixture and throttling governing. The actual proportioning of gas and air is accomplished by two plug valves at the bottom and the top of the mixing chamber, respectively, each with graduated index. These valves may be set by hand at any time to accommodate varying qualities of gas. An automatic diaphragm pressure regulator reduces the pressure of the incoming gas to atmosphere at the engine.

ENGINE AUXILIARIES.—Each igniter plug has two sets of points, each set independently connected. Should one set of points, through any cause, become unfit for use, a small double throw switch may be reversed, thus turning the ignition current through the other set of points. Three independent sources of current have been provided, all of the apparatus being contained in a general ignition cabinet. For starting, one of two 8-volt storage batteries is used. For running, a small 1½ KW. motor-generator unit is used delivering 110-volt current to the igniters through incandescent lamps, which furnish a valuable "tell-tale" for "open circuits," "grounded igniters," or "hanging fire" of igniters. These two sets of storage batteries are charged alternately through a bank of lamps from the motor-generator or from the main station bus bar, one or the other set being always available in an emergency. By means of small double-pole switches at the igniter cabinets, the change over from the low to the high-tension system may be instantly accomplished without in the least disturbing the engines. The ignition problem has thus been handled with great care in the provision of six individual combinations of current supply.

Another important part of the plant equipment is the circulating water system for cooling jackets, combustion chambers, and exhaust valves. Motor-driven rotary pumps are ideally suited to this work on account of the moderate pressure required—about 25 lbs. per sq. in. Two of these pumps (one for relay) serve the engine plant, while a third, of the two-stage turbine type, serves the gas producer scrubber in which a higher pressure is desirable. Although each pump is driven by a 15-HP. motor, the power ordinarily required is considerably less than this, especially in moderate and cold weather when the quantity of water supplied to the engines may be largely reduced by throttling the pump outlets.

COOLING RESERVOIR.—The pond which is used for cooling, has a normal depth of 10 ft. with a total capacity of about 1,000,000 gals. It is approximately semicircular in plan and is divided radially into two compartments to separate the comparatively dirty scrubber water from the pure jacket water. All make-up water used at the plant is delivered to the pure water pond through the engine jackets.* The excess overflows into the scrubber water pond and thence to the sewer. Cooling water for the engine is drawn from near the bottom through a screen house, while the hot jacket water is returned to the surface of the pond, about 150 ft. distant. During the progress of the water from inlet to outlet, enough heat is dissipated to the earth and atmosphere to reduce the outlet water to the proper temperature. During periods of extreme heat and humidity when the cooling process is retarded, a larger quantity of water may be sent through the jackets to compensate for the lesser difference in temperature.

On a fair day with practically seven-tenths load on the plant there was a difference in temperature of 1.8° F. in 8-ft. depth of water, 0.9° F. difference between the temperature of reservoir at intake and outlet, 4.6° F. difference between air and mean reservoir temperature, and 23.2° F. total cooling. Apparently, considerable cooling took place through the transmission of heat through the bottom of the reservoir.

PIPING.—The engine exhausts all discharge into a cast-iron header running beneath the floor to a concrete exhaust well outside, serving as a muffler. In cooling the exhaust valves, a fairly constant supply is desirable, irrespective of the load. The arrangement shown in the sketch, Fig. 4, is therefore employed by which the jacket water may be throttled as much as desirable, while constant head is maintained at the exhaust valves.

OPERATION OF THE ENGINES.—Practically the only trouble experienced thus far has been the occasional cutting of an exhaust valve, presumably due to cumulative carbon deposits on the valve seats. The lampblack has also occasioned some difficulty in lubricating valve stems. Usually one igniter will last from six to nine months without repointing. Since commencing normal operation, engine repairs have been confined to these two items and are comparatively light considering the conditions of operation.

In starting and stopping the engines, the attendants have acquired so much skill that the barring lever is seldom used. By manipulating the air valves just as the engine comes to rest it is not difficult to bring the air cams in starting position so that no time need be

*Abstract of a paper presented at the New York meeting (December, 1906) of the American Society of Mechanical Engineers.

†Associated with the Westinghouse Machine Co., E. Pittsburg, Pa.

*It is of interest that nearly all of this "make-up" water is supplied from roof drainage. City water being comparatively expensive (10-15 cts. per 1,000 gals.), this utilization of roofage insures an important economy. The pond also supplies feed water for some steam boilers.

lost in barring the engine around to the position for starting.

THE PRODUCER PLANT.—A notable feature of the producer plant is that it is capable of gasifying bituminous coals without making quantities of tar. The process is intermittent, embodying the now more or less well-known system of passing the green hydrocarbon distillates through a secondary fire bed which has previously been brought up to the proper temperature by blasting with air. Since the plant was started, a fair grade of soft coal, averaging about 13,500 B. T. U. per pound, has been used.

Straight producer gas is not made directly, but water gas and air gas are made at alternate intervals of varying duration according to the richness of the gas desired. The two gases are mixed in a single holder in the proportion generated.

PRODUCER OPERATION.—The present method of operating the producer plant requires an air gas run of 10 to 15 mins., according to the demand for gas at the power plant, and a water gas run from one-half to three-quarters of a minute, the resulting mixture being well suited to power work.

Frequent testing of the quality of the gas made is not now practiced on account of its uniformity under the present operating condition. The holder, of course, greatly assists in insuring uniform gas at the engines. At the same time it provides sufficient capacity for operating one unit at full load for about three-quarters of an hour; the full plant in inversely proportionate time. Storage capacity is particularly valuable when a new fire is being put into service. This is usually done during the noon hour when the load is light, so that a lowering of the heat value of the gas is relatively unimportant.

In ordinary operation it is a simple matter to observe the quality of gas by means of two sampling flames always in view of the operators. One consumes gas from the holder; the other consumes freshly made gases as they leave the dry scrubber. Any irregularities may then be readily detected. Calorimeter tests show the gas as made at the present time to average slightly above 100 B. T. U. per cubic foot.

Coal consumption is determined by direct weighing in the producer house. Each shift weighs up enough coal at the start to run the plant through 12 hrs.; should there be a surplus at the end, it is weighed back and charged to the next shift, thus making each shift responsible for all fuel used during their run.

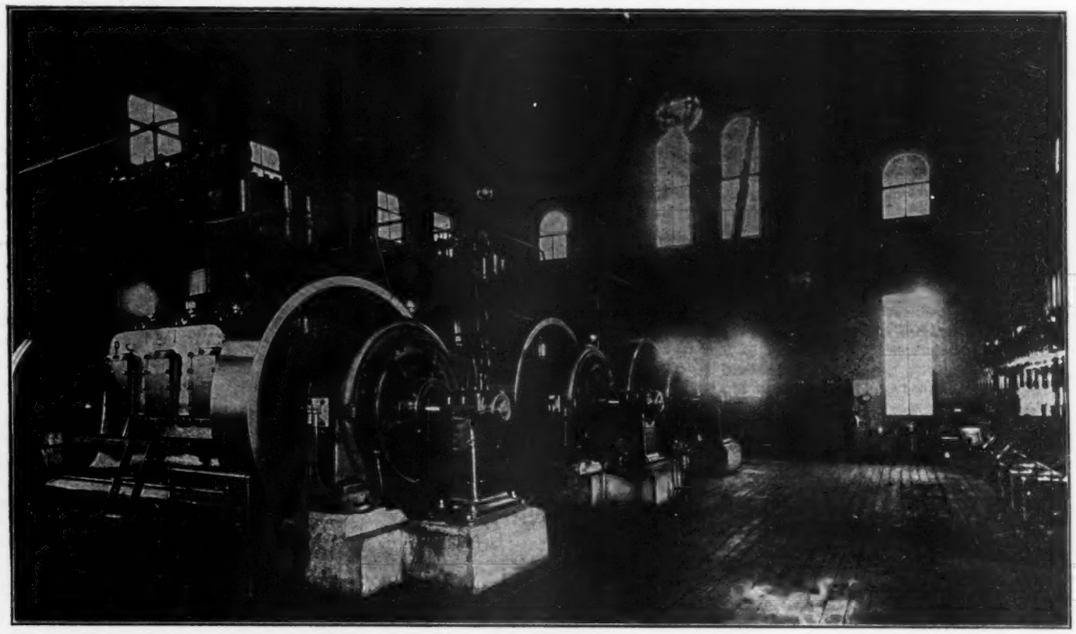


FIG. 2. INTERIOR OF THE POWER STATION. THE IGNITER CABINET MAY BE SEEN AT THE REAR WALL, AND THE STORAGE BATTERIES ARE IN THE BASEMENT.

producer, a sufficient quantity to affect the coal consumption of the succeeding day. If allowed to form to any extent, clinker constitutes a frequent source of trouble in operating the plant, and it is important that the selection of coal be made with this in view. With fire fairly free from clinker the suction required for blasting may be only 8 to 10 ins. of water, but with fires badlyl clinkered it may run up to 25 ins. With 10 to 15 ins. drop in the scrubbers, this imposes from 30 to 40 ins. suction on the exhauster, thus largely increasing its steam consumption.

THE EFFECT OF MOISTURE ON WOOD as regards its strength and stiffness has been studied for the past three years by the Forest Service of the United States Department of Agriculture. It was found that proper drying very greatly increases the strength of all kinds of wood, the amount of increase in strength depending upon the species and the dryness. The strength of unseasoned red spruce, for example, may be increased over 400% by a thorough drying at the temperature of boiling water. Wood decreases in strength again, as it absorbs moisture, and becomes slightly weaker than when green. Air-dried wood, protected from the weather, and containing 12% of moisture, is from 1.7 to 2.4 times stronger than when green, varying with the species. Stiffness is also increased by drying. These conclusions, however, are drawn from small sized pieces not exceeding 4 by 4 ins. in cross-section, such as are used in vehicle work, tools, etc. Large timbers require years of drying before the moisture is reduced to the point where strength begins to decrease. More or less checking always occurs when large timbers dry, and if this checking is excessive it may cause weakness. The fiber saturation point varies with conditions and species of wood, and designates the percentage of water which will saturate the fibers of the wood. Under normal conditions, wood fiber will absorb a definite amount of moisture; beyond this the water simply fills the pores of the wood like honey in honey-comb. Only that water which permeates the wood fiber has an influence upon the strength. In the following species, the saturation point occurs at the given percentage of moisture based on the dry weight of the wood.

Longleaf pine	25%	moisture.
Red spruce	31%	"
Chestnut	25%	"
Loblolly pine sapwood	24%	"
Red gum	25%	"
Red fir	23%	"
White ash	20.5%	"
Norway pine	30%	"
Western tamarack	30%	"

The strength of green wood is not reduced by prolonged soaking in cold water, below that of its fiber saturation point, provided the wood remains in perfect condition. Wood soaked in heated water absorbs more moisture because the heat causes the fiber's capacity for water to increase. This causes a reduction in strength and stiffness. Wood heated or steamed for bending suffers from this cause.

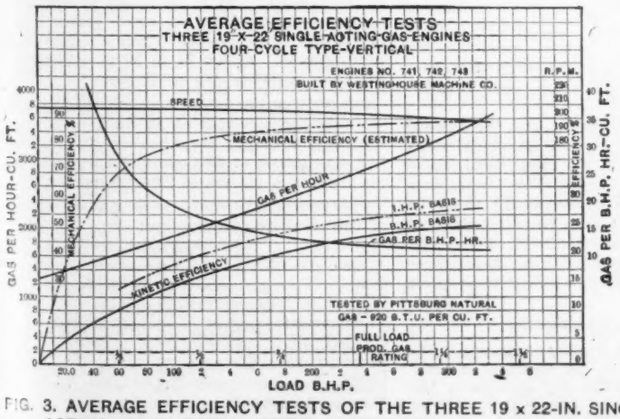


FIG. 3. AVERAGE EFFICIENCY TESTS OF THE THREE 19 x 22-IN. SINGLE-ACTING, FOUR-CYCLE VERTICAL GAS ENGINES SHOWN IN FIG. 2.

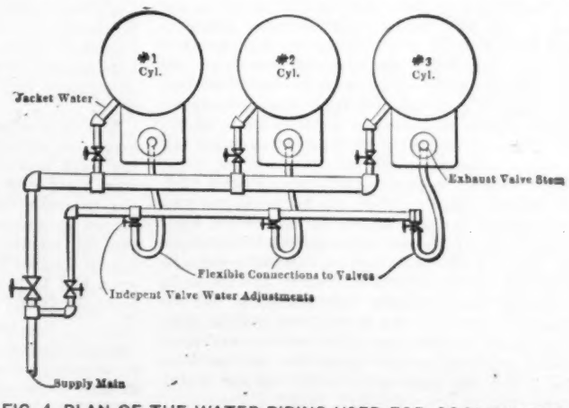


FIG. 4. PLAN OF THE WATER PIPING USED FOR COOLING THE ENGINE CYLINDERS AND EXHAUST VALVES.

The entire producer plant is operated throughout the week by four men, two to a shift, with some additional labor on Sundays for cleaning. All the attendants were unskilled foreigners before taking up the producer work. During a half-day shut down of the plant on Sundays, all renovating of the producer equipment is done; boiler tubes are cleaned, wet scrubber washed down, the excelsior in the dry scrubbers taken out and shaken free from lampblack, gas mains flushed out, and a new fire started in the idle producer. At the same time, another producer is taken out of service, fires are drawn, and during the week, after it has had an opportunity to cool off, the hard clinker, which adheres to the lining, is broken off. For the starting layer of a new fire bed, coke is used to the extent of some 3,000 lbs. per

EMERGENCY AIR-LIFT EQUIPMENT FOR DEEP WELLS, MARION CITY (O.) WATER CO.

By Edward H. Cowan.*

The Marion City Water Co., of Marion, O., gets its water supply partly from springs and partly from a series of ten wells, drilled from 100 to 200 ft. deep, into the underlying limestone rock. The springs were originally the only source of supply, but in consequence of the rapid growth of the city they became, in course of time, inadequate during dry seasons, and in 1895 the wells were drilled. Since that date the growth of the city has been even more rapid, and the time was rapidly approaching when there would be danger that, during periods of low water, the demand would exceed the supply.

In considering what should be done in the matter it was apparent that the present supply was ample for ordinary needs for many years to come, except during dry times, and that even during the *ordinary* annual dry season, no further supply would be necessary for several years, unless there should be an unusual drouth, such as comes once in five or ten years. Consequently it was not considered bad business judgment to use means for increasing the supply which should be relatively expensive to operate, provided the first cost be small, and it was decided to install an air-lift system, so arranged that when the supply is sufficient, pumping from the wells will be direct, and at other times the air-lift plant will be used. This arrangement possesses some unusual features, and a brief description may be of interest.

The new system was placed in only seven of the ten wells, and the arrangement of pipes, valves, etc., at each well is so clearly shown in the accompanying illustration as to require very little explanation. The concrete chambers serve to make the valves and piping accessible, besides obviating the necessity of the customary central collecting tank, or cistern. They replaced old wooden boxes, or manholes, in use before the air-lift plant was installed.

The compressed air supply pipe contains, in addition to a globe valve, a float valve, which causes the water in the tank to remain at a constant level, by regulating the supply of air. Should all seven of the float valves become closed at once, the compressor engine would stop, as it is governed automatically by the air pressure. As an additional precaution a safety valve was placed on the receiver. It has been found in practice that usually all the governing has been done at one well, the float valve of which closes before the others start to close. This may be due to slightly better air pressure at the well in question, or a freer supply of water at the bottom of the well, or to both causes.

The "well head casting" is like an ordinary 8x6 reducer, except that a shoulder was cast on the inside at the lower end, to rest on the upper end of the well casing, and the joint made up with lead, instead of a threaded joint. This construction was made necessary by reason of the fact that the concrete floors of the chambers had been put in place at the time the wells were drilled, and came so nearly up to the level of the top of the casing that there was not room enough to cut a thread on the latter.

The "free air supply" pipe communicates with the annular space between the inside of the well head casting and the outside of the suction pipe. It was thought necessary to provide these pipes, lest when pumping direct a partial vacuum should be formed at the surface of the water in the wells, thus reducing the efficiency of the pumps, as well as the depth from which they would draw the water. The mushroom-shaped casting screwed to the upper end of the 6-in. pipe is for the purpose of deflecting the water downward.

When pumping direct, the gate valve at the upper end of the 6-in. pipe is closed, and the three-way cock is so turned that the side outlet is closed, and the ends toward the pumps and toward the well are open, thus providing a direct waterway from the well to the pumps.

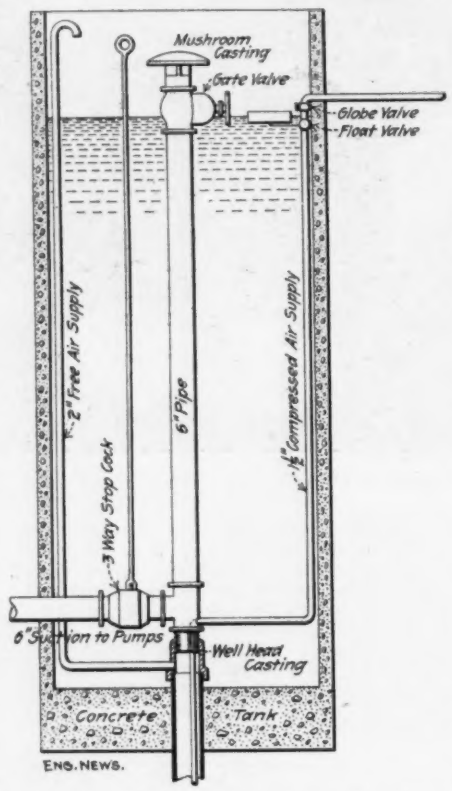
When the air-lift is in service, the gate valve stands open, and the three-way cock in such position that the side outlet and end toward the pumps are open, and the end toward the well is closed, the water being raised to the top of the 6-in. pipe, overflowing to the tank, and passing through the three-way cock to the pumps.

The system has been given a thorough trial, and all the details are found to work in a very satisfactory manner.

The cost of the installation was as follows:

Compressor	$1,348
Receiver	178
Pipes, valves and fittings	843
Crushed stone and cement	259
Labor	410
Total	$3,038

The receiver was made from the shell of an old boiler. Some of the pipe, valves, and fittings, notably the 6-in. gate valves and considerable 6-in. pipe, were already on hand, and did not have to be bought.



Emergency Air-Lift Equipment for Deep Wells, Marion City, O.

Sand for the concrete was found on the Water Co.'s land close by, and the cost of getting it out is included in the labor item. The cost of labor is less than it otherwise would have been, because considerable of it was done by pumping station employees, when not busy about their regular work.

The excavation for the tanks and the bottom layers of concrete were already in place when the work was started. On the other hand, there was great difficulty in placing the forms, and the concrete was made unnecessarily thick in places, on account of the fact that the sides of the old wooden boxes, or manholes, were very nearly tangent to the circular forms, and, moreover, had to be kept braced, as they were quite badly decayed.

*Marion, O.

MECHANICALLY-DRIVEN FIRE APPARATUS is to be adopted in the City of Berlin, Germany, in place of horse-drawn apparatus. The city government has taken steps to make long-time comparative trials of an electrically-driven apparatus truck and a steam-driven engine, for the purpose of indicating which form of driving power is the better. Both vehicles will make daily runs, to aggregate 6,200 miles, the estimated total travel of a Berlin fire unit in 10 yrs. The sum of 50,000 M ($12,000) has been appropriated for the trials. Benzine motors as motive power will not be considered, because of their greater fire danger and their lower reliability.

COST OF A 66-IN. REINFORCED-CONCRETE SEWER AT SOUTH BEND, IND.

A 66-in. circular trunk sewer has been built along Kenwood Ave., South Bend, Ind., during the past year as an extension of the combined sewer system of the city. The extension is about 2,500 ft. long, and adjoins a length of about 3,600 ft. of 72-in. and 66-in. sewer built in 1905. Both sections are of reinforced concrete. Some figures on the cost of the construction done during the present year have been given us by Mr. A. J. Hammond, M. Am. Soc. C. E., City Engineer of South Bend. We reproduce them here with a brief description of the work to which they apply.

The 66-in. reinforced-concrete section consists of a 9-in. ring, whose sides below the center line are vertical for a depth of 30 ins., to form a horizontal footing on either side near the lower quarter. Between these footings the bottom of the sewer is completed by an invert 9 ins. thick in continuation of the 9-in. roof arch, the invert covering about a quarter-circle. The roof arch is reinforced by $^{5}/_{16}$ × 1-in. circumferential bars 3 ins. from the inner face of the ring, spaced 12 ins. on centers. These bars terminate near the horizontal center line, and are spliced to vertical pieces of the same cross-section set 15 ins. in the concrete of the lower half and bent over at right angles at their lower ends. The splices are made by pins held by cotters.

The sewer was built in sheeted trench, wide enough to give 12 ins. clearance on either side between the sheeting and the side of the sewer, the bottom of the trench being formed to the shape of the sewer base. The concrete work then proceeds in three stages: (1) The invert, including the sides up to a level 15 ins. below the center line, is placed between vertical side sheeting and a circular invert form braced to cross timbers above. (2) The vertical anchor strips of the reinforcing bars, which extend down to the top level of the invert concrete, are set in place and firmly held by being nailed to studs projecting from the posts of the outside form; the concrete is then carried up to the center line, or spring of the arch, segmental inner forms, cross-braced to each other, being used. (3) A semi-circular arch form in two vertical halves is set upon the segmental forms of the sides, the reinforcing rings are set and keyed to the anchor strips, and forms for the external face of the arch up to the 45° point are set and braced to the trench framing, whereupon the concreting of the semicircle of the arch is completed in one operation. The work is done in 12-ft. lengths, and each of the three stages of concreting extends over several lengths. The concrete is handled in wheelbarrows.

The forms were kept in, as a rule, for about 14 days, though the back-fill was put in as soon as the concrete was hard enough to bear it. The stock of forms kept on hand corresponded to about 200 ft. of sewer. Their average life was four months. About 24 to 36 ft. of sewer were built per working day of 10 hrs.

Considering the concrete construction alone, the working force comprised 12 men, at the following rates of pay: Six wheelers, at 18½ cts. per hr.; one mixer at 22½ cts.; one dumper at 18½ cts.; and four placers at 22½ cts. per hr.

The following items of cost are representative of the concrete construction:

Item.	Cost per Unit.	Cost per cu. yd of concrete.
Gravel	$0.90 per cu. yd.	$0.774
Sand	0.90 " "	0.36
Cement	1.50 per bbl.	1.50
Reinforcement	0.50 per ft. of sewer	0.841
Labor mixing and placing	0.65 " "	1.094
Labor, moving and setting forms	0.45 " "	0.757
Forms	0.35 " "	0.589
Finishing	0.38 " "	0.639
Tools, gen'l expenses, etc.	0.50 " "	0.841
Cost per cubic yard of concrete		$7.395

Concrete per lin. ft. of sewer, 0.594 cu. yds.
Cost per lin. ft. of sewer, $4.39.

The contract unit-price for the entire work, excavation, concreting and back-fill, was $9.50 per lin. ft. of sewer. Hoban and Roach, of South Bend, were the contractors.

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A famous engineering feat—the work of tunneling under the Hudson River for the Pennsylvania Railroad's extension into New York—is described at length in this issue by Mr. James Forgie, one of the engineers in charge. In a second paper, shortly to appear in this journal, Mr. Forgie records the methods of working in the several kinds of ground encountered, and the special phenomena which were observed in the soft river mud which forms the bed of the Hudson. These two papers constitute as important a monograph on soft-ground tunneling as has ever been published.

We need hardly say to our readers that soft-ground tunneling on land ranks among the most difficult classes of engineering work, and that soft-ground tunneling underneath a river or other body of water is even more doubtful and risky. This is true even under ordinary conditions, where the engineer has, when his tunnel is finally completed, a reasonably firm foundation on which his structures can rest. But the engineers who grappled with the Hudson River tunnels had the added complication that the soft, flowing mud to be penetrated furnished no secure foundation for the tunnel structure.

It is interesting to note that a somewhat similar condition proved to be the greatest difficulty in the construction of the Simplon tunnel, completed last year. Under the enormous pressure of the overlying mountain mass the solid rock at many points was unable to hold the shape of the tunnel walls, and slowly flowed into the tunnel, threatening to obliterate it entirely. Before this difficulty was overcome it was easily the greatest menace to the successful completion of the undertaking. The condition was not wholly novel in rock tunneling, but in view of the magnitude of the forces at work in the Simplon it formed a virtually unprecedented difficulty.

Just as the completion of the Simplon tunnel marks an epoch in rock tunneling, so the completion of the Hudson River tunnel sets a new standard of achievement in soft-ground working. The "Old Hudson River Tunnel," at Morton Street, New York City, is indeed a forerunner, since it was both begun and completed before the Pennsylvania tunnels, and passes through the same material. But the history of that work must be considered: Begun in the late 70's for a railway tunnel to New York, it was several times abandoned, the engineering difficulties being so great that financiers would not furnish money for the work, doubting whether success were possible. When taken in hand again, four years ago, a part of the iron lined section proved to be in bad shape, so that progress under the old plans was impossible. The same diameter was maintained into New York, but the interior of the defective sections was strengthened and lined with reinforced concrete, and the diameter was decreased from the size for main-line traffic to the dimensions required for rapid transit traffic. The tunnel is to be used for a special rapid transit service as the weight and inpact of heavy main-line trains is believed to be beyond the strength of the tunnel structure to carry without exterior foundations to assure its stability. Indeed, the opinion may now be ventured that the original tunnel could never have been operated for such service, if indeed it could have been completed. Considering the time at which it was begun and the resources then available to the engineer, the undertaking was surpassingly bold.

In contrast with the checkered history of this enterprise, we have the Pennsylvania tunnel completed without serious incident, and according to the original project, in less than three years from beginning; built for the heaviest class of railway service; its shields meeting edge to edge with mathematical precision. Through the original idea of external foundations for the tunnel lining and the prospective success of these, it affords in fact a new type of soft-ground tunnel.

Less than two miles east of the Pennsylvania Railroad's Hudson River tunnels, and almost in their prolongation, are the East River tunnels, now under construction, another section of the same huge undertaking. The East River tunnels, a group of four single-track tubes, pass through material very different in its general nature from that under the Hudson, although similar in some respects to the material pierced on the land sections of the Hudson River work. The East River excavation is largely in sand, gravel and rock which is cut across by sheets of soft and broken material in a way to make tunnel construction exceedingly difficult. The novel expedient of the Hudson River tunnel builders—foundations sunk from the tunnel down to firm ground—will not be required here. But the difficulties at the face of the tunnel are probably as great as those met by the Hudson tunnel builders in driving their land sections.

Some months ago (in our issue of July 12, 1906) we illustrated the shield designed for the East River work. Students of tunneling will find it interesting to compare this with the North River shield, fully described in this issue. It will be seen that the two designs are fundamentally different: the East River shield, with its provision for airlocks, its differential pressure, its material chutes, and its power-operated outer hood, represents an endeavor to make available in a single structure every resource of pneumatic tunneling. The Hudson River shield in comparison is of extremely simple design; the power-operated sliding platforms, the removable hood and segmental doors are the only devices which have been added to the bare essentials of a hydraulic shield. The difference is due to the provision for differential pressure in the East River tunnels, with the purpose of maintaining the working face under the worst conditions, while in the Hudson River shield the shield-diaphragm itself, in conjunction with thorough timbering of the face, was relied on for ensuring safety, continuity and expeditious working.

One might conclude, from the striking difference between these two shields considered either as structures or as working machines, that the differences in the material to be handled were responsible, each designer aiming to produce the most suitable shield for his particular material. We are informed, however, that the Hudson River shield was designed without special reference to the Hudson silt, but solely with a view to ensuring safe and expeditious working against the most treacherous face anticipated. The Hudson silt was therefore by no means the governing feature. Greater difficulties were expected and were later encountered in the short sections of water-bearing sand and gravel, and in passing through piling, alternate rock and sand faces and riprap foundations.

Railway maintenance-of-way expenses are increasing materially with the increase in traffic and particularly with the rapidly extending use of extremely heavy engines, but the relations of track condition and maintenance expenses to the traffic and equipment and the general operating expenses do not receive the importance which they merit, and in very many cases the track is not adapted to economically sustain the service now imposed upon it. That this is the case was shown during some of the discussions at the recent convention of the Roadmasters and Maintenance-of-Way Association, several speakers recounting their difficulties in holding the track to its proper line and surface under the disturbing influences of modern equipment and traffic conditions.

The difficulties of the department are further increased by the troubles now found in obtaining and keeping in the track department men who are competent to have charge of modern maintenance work, owing largely to the low rate of wages and the few opportunities of advancement which this service offers.

The lack of definite and detailed records of maintenance-of-way expenses was discussed at some length in our issue of July 5, 1905, and attention is again called to the matter by the recent annual reports of a number of railway companies. The renewals of rails and ties represent about 20% of the total expenses for maintenance of way, and an examination of the annual reports of a number of railways shows that the tie renewals represent about 14% and the rail renewals 6% of the amount. Of twenty important railways aggregating about 45,000 miles of line, the annual cost of rail renewals amounts to $4,500,000 and the tie renewals to $9,000,000, or $100 and $200 per mile, respectively. These figures are, of course, very indefinite, but they indicate the general trend of the expense account.

The high cost of tie renewals as compared with that of rail renewals has been a feature of maintenance work for several years, and out of the twenty railways in question only one shows a higher cost for rail renewals; that road is the Denver & Rio Grande Ry., with $340,923 for rail renewals and $257,896 for tie renewals. On the other hand, the cost of tie renewals is in some cases even three times as great as that for rail renewals.

The figures given in the annual reports are too general to allow of any close deductions, but it is worth noting that on the Atchison, Topeka & Santa Fe Ry., which has made extensive use of treated ties for several years, the cost for the two items is very nearly the same: $1,384,264 for rails and $1,654,842 for ties. Under the general practice of lumping together the cost of maintenance of track and structures, it is difficult to make any satisfactory analysis, but it can be stated that in the ten years, 1897-1906, this class of expenditure on the Atchison, Topeka & Santa Fe Ry. increased from $975 to $1,479 per mile, the lowest figure being $781 per mile in 1902. On the Illinois Central R. R. these expenditures increased during the same term from $1,148 to $1,549 per mile, but they have averaged higher than on the former road, while the minimum was $1,127 in 1898.

It would seem that the expenditures in the Maintenance-of-Way Department on many railways have become of sufficient importance to warrant careful investigation, especially on roads where the weight and amount of traffic show material increase, the investigation being made with a view to determining whether it might not be real economy to put some heavy expenditures upon the construction of a track of more substantial and permanent design, which could carry the traffic and equipment with less cost for maintenance and repair, and with greater safety.

The article on an emergency air-lift equipment for deep wells, described elsewhere in this issue, is commended to the attention of our readers (1) as descriptive of an ingenious but simple piece of engineering work that might be applied elsewhere to advantage, and (2) as an example of a

short, practical article likely to interest many readers. There are few engineers, indeed, whose experience does not frequently supply material for articles equally valuable. Comparatively few such articles are written, largely because it is thought that length is a measure of the value of the article. No article is too brief, so long as it tells all that needs to be told to convey to a brother engineer how some problem has been solved in a novel or otherwise interesting and instructive manner.

A FORWARD MOVEMENT IN THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The very successful annual convention of the American Society of Mechanical Engineers, held in New York City last week, impels us to call attention to the notable advance which this Society is making. The total registration in attendance at last week's meeting was 1,325, breaking all records for convention registration, not only for this Society, but for any other American engineering society, so far as we recall. No other engineering society compares with the Mechanical Engineers in the matter of convention attendance. One reason for this, of course, is that the membership of the Civil and Mining Engineering Societies is much more widely scattered, and also that a large proportion of the Mechanical Engineers are able to combine business with pleasure in attending the annual meeting at New York City.

Making all allowance for such conditions as these, however, it is certainly true that the enormous attendance at the Mechanical Engineers' conventions shows a lively interest by the members in the Society's work.

It is, of course, recognized that one of the principal functions of this and of any engineering society is the promotion of acquaintance and social intercourse among the men engaged in the same line of work. The social features have always been prominent in this Society and account in some measure for the very large attendance at the Society's conventions. It still remains true, however, of this as of other national engineering societies, that the majority of the members are seldom able to attend meetings of the Society, and the value of their Society membership—or what they get, in return for their annual dues of $15—is measured by the value of the Society's publications.

It is therefore a matter of great importance to the Society's welfare that the quality of the papers presented at the meeting last week, rating them as a whole, was far in advance of those at any previous meeting in a long time. In addition to this, the discussion on the papers was of real importance and value, and the whole meeting represented a most praiseworthy result in valuable technical work accomplished.

Like most valuable results, the success of last week's meeting was not brought about by accident, nor did it, like Topsy, "just growed." It represented some of the results of the work which Mr. Frederick H. Taylor has done for the Society during the year in which he has been its executive head.

The man who is chosen to the presidential office of a national engineering society commonly regards the matter chiefly in the light of receiving a great honor at the hands of his professional brethren. He attends and presides at meetings of the Society and its governing body, when he can conveniently do so, and lends such dignity as he can to the office. There is, however, another light in which to view the office of President, and that is as the executive head of a business corporation receiving and expending nearly $50,000 a year and accountable to several thousand shareholders for the economical and efficient handling of this income.

As we have said above, President Taylor has been the executive head of the Society. He has expended a very considerable amount of time and money in reorganizing the Society's business affairs. Its work in printing and publication has been carefully investigated by an expert employed by President Taylor at his own expense, and changes in methods and in contracts for printing and publication have been made which will effect a large saving in the Society's expenditures. In connection with this, the old plan of issuing advance copies of papers just prior to each meeting has been abandoned, and in its place the publication has begun of a monthly "Proceedings," in which the papers are printed as fast as received and, of course, before their presentation at a meeting. Coincident with these other changes has been the installation of a new Secretary, Mr. Calvin W. Rice, late Consulting Engineer of the General Electric Co. While Mr. Rice has been serving as Assistant Secretary since last April, and has only been advanced to the position of Secretary at the annual meeting last week, it is only giving credit where credit is justly due to say that the high quality of the papers and discussions at last week's meeting was largely due to Mr. Rice's initiative and energy.

It is something of an innovation to select as Secretary of an engineering society an engineer of high standing in practical engineering work and have him devote his entire time to the Society's affairs. A frequent criticism of the Mechanical Engineers' Society in the past has been that the papers read before it were too largely contributed by professors and dealt with theoretical matters or laboratory tests rather than with practical present-day work of the engineer. It may be expected that the selection as Secretary of a practical engineer of wide experience will have a strong influence to reform the Society's work in this particular.

We may set down here that the task of procuring first-rate technical literature for publication is harder in this field by far than it is in the field of civil engineering. Of third-rate, fourth-rate, and so on down the scale, an infinite amount is to be had for the asking—or without the asking. There are plenty of people who want to advertise themselves or their products. First-rate literature, however, is the sort that is of direct practical usefulness to the working engineer, and the attempt to secure this sort of papers is met too often by the refusal of business firms to permit the data obtained by engineers in their employ to be made public. This refusal, be it said, is due more frequently to red tape and to cast-iron rules regarding secrecy, than to any real injury which would be done to commercial interests if the data in question were made public. Nevertheless, the condition referred to exists and must be dealt with by those who are tackling the job of making the American Society of Mechanical Engineers the useful aid to the profession that it ought to be. Mr. Rice as Secretary is preeminently fitted for the work of educating our great industrial corporations to the advantages of technical publicity—of a different sort from that promoted by their own "publicity" men.

In another respect, too, the Society is soon to enter on a new era in its existence. A few weeks hence it will leave the house on 31st St. where it has been quartered for sixteen years and move into the spacious new home of American engineering societies which has been created through Mr. Carnegie's generosity, and which is to be the home as well of the Mining Engineers and the Electrical Engineers, the two other "Founder Societies," and also of a number of other engineering and scientific societies, of national or local scope.

The attractive features of this new headquarters, with the library and social facilities which will be there available, are certain, we believe, to attract a large number of new members to the organization.

LETTERS TO THE EDITOR.

Typhoid Mortality and Fatality Among the Colored People at Washington, D. C.

Sir: Referring to article on Prevalence and Causation of Typhoid Fever in Washington, in your issue of Nov. 8: Fig. 1, p. 485, shows a typhoid death rate of 43.8 per 100,000 for the year 1905. On p. 486 it is stated that this number of deaths per 100,000 is divided between the negroes and whites in the following proportion: whites, 15.1; negroes, 28.7. It is also stated that the colored population is about 30% of the total, which makes the typhoid death rate for the whites considered by themselves, 15.1/0.7 = 21.6 per 100,000, and for the negroes, 28.7/0.3 = 95.7 per 100,000. As stated by the author, the classification by races is of no particular bearing on the problem; still so great a difference seems very remarkable, and I write to inquire if this interpretation of the figures given is the correct one.

Yours truly,

Clarence W. Hubbell, M. Am. Soc. C. E.

Detroit, Mich., Nov. 12, 1906.

[We have submitted the foregoing letter to Mr. Horton and print his reply below.]

Sir: I have reviewed carefully and with much interest Mr. C. W. Hubbell's criticism of the paragraph of my Washington report referring to the relative population and mortality statistics among the white and the colored race of the District of Columbia. His exception was well taken, for I find that the *mortality* statistics were erroneously presented instead of the *fatality* or *lethality* statistics. The paragraph in corrected form should read as follows:

Another classification was made between the white and colored population. The colored population is about 30% of the total population of the District, whereas the fatality or lethality from typhoid fever (i. e., the rate of deaths to cases) among the colored race is considerably in excess of that among the white race, being, in 1904, 22.42% for the colored race and 10.89% for the white race. In 1905 these percentages were 16.05% and 11.68%, respectively. This is a very important fact, for it gives a considerably higher total death rate from typhoid fever for the District than would occur if the population were mostly white, as in cities located further north. This classification by races has, however, no particular bearing upon the relative prevalence of typhoid fever for this year, since the conditions for this year, so far as I could learn, are not materially different from that during recent years.

I was pleased to have this inconsistency called to my attention and hope the above will more clearly explain the point intended to be brought out in my report.

Very truly yours,

Theodore Horton,

Consulting Engineer, State Department of Health.

Albany, N. Y., Dec. 4, 1906.

The Planetable and Stadia in Railroad Surveys.

Sir: Your correspondent, Mr. John W. Hays, in your issue of Nov. 15, 1906, criticizes what he calls the "slighting and disrespectful manner in which the subject of the planetable and stadia method of surveying is dismissed" in the writer's book on Railroad Location, and intimates that this is so because "well-worn trails" only have been followed. The writer fears Mr. Hays has either not read the book in question thoroughly, or has not understood what it was desired to convey as to the essentials of railroad location surveys, this latter possibly due to the author's inability to properly express his meaning.

The book in question is not intended to cover the whole field of surveying, as might be imagined from the first part of your correspondent's letter; and the merits of planetable or stadia surveying per se are not therefore discussed, although their applicability or otherwise for railroad location surveys is pointed out.

That the writer is an ardent advocate of the stadia (without the planetable) for reconnaisance, a careful reading of the book will show, and his opinion is summed up in the following quotation therefrom: "It may perhaps be advisable to reiterate the author's opinion as to the value of the stadia for reconnaissance for railroad surveys to the *absolute exclusion* of all other forms of instruments" and to amplify this, there is given a table for stadia reduction which as far as the writer knows is without precedent in any other book on railroad location or for that matter in any other book on any branch of railroad surveying.

The planetable is not advocated, even for reconnaissance, because the writer knows from actual experience, with all methods, that the information which the experienced locating engineer (and none other should ever make a reconnaissance) needs from this reconnaissance, when anything more than a compass and hand-level is necessary, can be obtained more quickly and cheaply with the stadia, with notes recorded in a note-book, and platted afterwards (in camp at night), than by any other method. Even in a dry climate, where no delays might be anticipated from wet or damp weather, the writer would not use a planetable for this purpose, and in any climate where wet weather might be expected, the note-book method could be used on a great many days when a planetable could not.

The use of the planetable on preliminary surveys (as this latter term is understood among railroad engineers in this country) is out of the question, as it would almost seem your correspondent must know. In making the preliminary survey, for very many reasons too numerous to even enter into here, but which are familiar to locating engineers, it is necessary to stake out a line on the ground, with one stake at least every hundred feet; it is also necessary to take levels over this line to obtain a profile of it. This being done, there is no question

whatever that the general methods advocated by the author for taking the topography are superior in point of cost, time required, and accuracy within the required limits, to any others. This is not the writer's opinion alone, but the results of actual experience with very many old and experienced locators who have tried everything to get the best and cheapest methods of obtaining the necessary results.

For detailed topographical surveys of an area, where the view is unobstructed by underbrush, the planetable is eminently adapted, but the writer would like to see what your correspondent would do with one in getting topography for say 300 ft. on either side of a line chopped through 30 or 40 miles of dense underbrush or fallen timber; and even in ordinary country it is quite frequent that the line passes through stretches of a mile or two in length where conditions obtain which would preclude the use of the planetable, even if it might be used in the open portions; but even in the most open country, once the line is staked out and leveled over, two men with a hand-level and cloth tape can take more and better topography of the kind needed than the planetable man with his umbrella bearer and four or five rodmen.

The adoption of the planetable for railroad work is sporadically urged from time to time by someone who has made a new discovery of its adaptability for general topographical work, but never by any experienced railroad engineer, and the writer therefore, in spite of his ambition to branch out, is obliged to stick to the "well-worn trail" as far as the planetable is concerned for railroad location surveys..

Too many engineers lose sight of the fact that the ultimate requirement of a location survey, is *the located line, staked out on the ground*, and all other processes are, or should be, means to that end. Topography is necessarily, in quantity and accuracy, varying with the country and kind of line required. The great prejudice which has existed, and to a certain extent still exists, among many engineers who are responsible for the amount of money expended on surveys (and not a few of their subordinates lose sight of the fact that there is a limit, sometimes very small, in this regard) is due to the oftentimes excessive cost of getting it, in proportion to its value to the final result, and it is claimed by the author of "Railroad Location Surveys and Estimates" that this final result, namely, "the staking out on the ground of the best line the country affords" under the conditions imposed, may be obtained most quickly and cheaply by the general methods advocated therein, with necessary modifications to meet local conditions.

Yours very truly,

F. Lavis.

Mt. Vernon, N. Y.,
Nov. 26, 1906.

"The Lesson from Recent Failures of Reinforced Concrete Structures."

Sir: I rejoice to see how energetically you have opened fire upon bad work in reinforced concrete. It is high time. I believe more can be found in outright defects of design than has been shown up yet. Sometimes this bad design has not seemed the absolute proximate cause of just what happened but it is an excellent indication of the probability of other bad work likely to be a proximate cause and it is taking inexcusable chances to tolerate such things, whether they have been found to be proximate causes in actual failures or not.

Very truly yours, J.

Boston, Mass., Dec. 4, 1906.

Sir: Your recent editorial on the lesson from failures of reinforced concrete structures is an able opinion rendered at a proper time.

However, there is one feature not touched upon which applies, more or less, to all work of this class, and that is the uncertainty as to how the work is actually executed. In spite of the most carefully prepared plans, it does not follow that the structure will be built exactly as shown on the plans, unless the greatest care and vigilance is observed.

In other words, the steel called for is not always inserted. The omission may not be intentional, by any means. In one case of failure, known to the writer, the steel was furnished by the owner, which should have been inserted in a lintel over an opening in a foundation wall, but through an oversight this was omitted. This would never have been known if it had not been for the fact that the lintel fell of its own weight after the forms were removed. It is easy to see that one such error or omission suffices to imperil perhaps the integrity of an entire structure, so that unless, during the process of construction of reinforced concrete, every operation is carefully observed at all times, it is impossible to say that the structure was built according to the plans. So that your correspondent in giving his views on the Bixby Hotel disaster, takes too much for granted when he eliminates the floor system from all suspicion, and fixes the blame either upon the finished columns, or the temporary wooden supports under the roof, or both.

The plans and photographs so far contributed by your correspondent are instructive, inasmuch as they show in a measure that the design was faulty at least in the connection of the girders to the columns, where it is customary to provide for the continuity by the use of knee braces under the girders. Moreover, the reinforcing over the points of the support, shown for the girder in Fig. C, p. 556, is deficient when compared with the reinforcing in the middle of the span. It is to be hoped that complete plans of this structure will be published, so that your readers can perhaps learn for themselves the cause of this terrible disaster.

In view of all the uncertainty that exists in all forms of reinforced concrete structures, before and after the forms are removed, the writer believes that this form of construction is only a stepping stone to something better, and that a combination of steel and concrete will be evolved which will eliminate all the uncertainties now encountered in this form of construction, and which will enable the designer to lay out his work on definite lines of safety at all times, and which will be more in line with the methods heretofore employed in the design of engineering structures.

Yours truly, J. W. Schaub.

Monadnock Block, Chicago, Dec. 3, 1906.

Sir: From a paper published in your issue of Nov. 29, 1906, under the above title, one may get the conviction that reinforced concrete buildings are not only less safe than all other kinds of structures, but are dangerous, and as such, their use should be restrained.

It seems to the writer, on the contrary, that reinforced concrete buildings are one of the safest which can be built. Any owner of a reinforced concrete building may be sure to possess a very safe one, which will grow stronger with time, as the concrete grows harder and harder. Should the building be of a poor design, or of poor workmanship, it will collapse under the test, or as soon as the centering is removed. It is easy to state that all failures of reinforced concrete buildings occur during the construction, and we should say, not that the building itself, but its construction is a very dangerous one. The design may be a perfect one, the materials used and the workmanship as to the concreting and placing of the reinforcement may be first-class, but if the centering is not strong enough or if it is removed too soon, disasters such as those at Long Beach, Cal., or at Kodak Park in Rochester, New York, may take place and cause loss of human life.

Failures of reinforced concrete structures are known to most architects and owners, and in most specifications you will find very rigid requirements concerning the brand of cement, the qualities of the stone and sand, the cross-section area of the steel, etc., but you will not find a word concerning the wooden centering. If the architect or owner has an independent engineer to see that the work is well done, this engineer will in most cases watch the ratio of the mixture, the cleanness of the stone and sand, and the sizes of the rods embedded, but he will not watch the centering.

It is not always the design of the reinforced concrete building, but the design of the centering which is all left to the contractor; and as the centering is not specified in the contract, and is to be removed, the contractor tends to use the cheapest lumber he can procure, and is always in a hurry to remove the forms and use them again and again. It seems to the writer that at the Bixby Hotel the contractor had used for the roof centering all the old and broken lumber that he could find on his job. The centering built with this lumber gave way and the concrete from the roof fell on the next floor, and as this floor was fresh and only designed for 60 lbs. per sq. ft., the heavy load went through and caused the deplorable disaster.

It seems further to the writer, that it is not a recommendable practice to fix the time after which the centering may be removed. The first condition is, that the concrete should be thoroughly set and the time limit is not always enough. A better practice is to concrete sample blocks with the same mixture and let them set under the same conditions as the structure, and test them before removing the centering. The setting of the concrete, especially in cool and wet weather, is not always the same, though the cement be of the same brand.

The writer has in his practice used this plan and obtained interesting hints as to the time of removing the centering. A safe practice is further to watch the centering during the concreting; by means of wooden strips fixed to the level and plumb bob on the centering, any moving of the centering may be recognized soon enough to stop the concreting and to prevent an accident. Also the removal of the centering should be done very carefully and the concrete structure watched, and the removal stopped, if necessary to prevent a collapse.

Yours very truly,

Michael Morssen.

71 Saint Alexander St., Montreal, Dec. 3, 1906.

Sir: I notice several articles in your paper of late date, suggesting the advisability of always employing an engineer to design and supervise concrete steel construction work, and these articles ordinarily suggest that the other means of proceeding where an engineer is not employed is to allow the contractor to suggest designs and proceed with the construction, according to his own ideas.

Now there is no question but what a competent engineer or architect should design and supervise all construction work, whether steel, concrete, or whatever else it may be, but may not this engineer also be a contractor, and may not the work be as safe in his charge where he is under bonds to secure required results, as well as having his reputation at stake, as though it is turned over to an engineer who quite often has no financial responsibility, and who may or may not be well informed in reference to the work which he proposes to design and supervise?

It is not my purpose to suggest that less than the ordinary care should be exercised in the selecting of the designer, or in the supervision of the work, as it is my opinion that the ordinary care as taken is not sufficient to secure such results as the owner expects, and should have, but the question is as to how the owner is most likely to be able to secure the services and results required.

There are at the present time, a multitude of engineers and architects who are advertising themselves as concrete specialists, and who are designing reinforced concrete work, but who have no financial strength, past record, or valuable results to their credit as evidence of their fitness to successfully undertake the class of work which they propose. We also find that there is hardly an engineer or architect throughout the several states in which we do business who is not ready to claim himself capable of designing and superintending reinforced concrete construction work, and the bulk of the small and ordinary size jobs are designed and inspected by such parties. There are a multitude of small failures in such work all over the country which do not come to the notice of the press, because of no special damage done, and because the extent of the failure is not sufficient to attract attention, and the cause of these failures are, in my opinion, as often the fault of the design and supervision as the ignorance and carelessness of the builder, which, as a usual thing, are surely up to the limit.

We have lately seen constructed under directions of architects and engineers 20-ft. floor spans made of reinforced cinder concrete 7 ins. to 7½ ins. thick, made in proportions of 1 : 2½ : 5, reinforced with light (16 gage) expanded metal and ⅝-in. to ½-in. round rods 19 ins. on centers, with the reinforcement often raised above the center of the slab in middle of span and a common thing for it not to reach to the bearing on the beam, stopping at any convenient place close to the beam.

We have also seen reinforced stone concrete columns and girders carrying cinder floor slabs up to 16-ft. span, with no adequate design for properly joining the beam and floor slab together so as to secure such compressive strength as there may be in the cinder slab, and designed upon the basis of the entire beam being constructed of a stone concrete, including the benefits to be derived from the T in the floor slab. Many other equally unreasonable propositions are constantly coming to attention and being offered by architects and engineers who claim to have knowledge in reference to such construction work.

There are any quantity of jobs throughout the country that are building upon such designs, and which either fail through, or in some other way show such weakness that the designs are changed, or are supported by additional columns or other supports before the construction work is completed, while many of such jobs are turned over to the owners for use with a factor of safety of less than two, and, in some cases that I have known, without sufficient strength to carry the load the floors are designed for, bogus tests having been made with knowledge of those in charge, and the work accepted to avoid complications and the necessity of placing the responsibility for the failure.

We know of floors large in extent and in public use that have sagged from the dead weight 4 ins. in the centers, and would to-day drop out if loaded to their supposed safe capacity, known by the owners to be in such condition, who have no recourse because there is no way to fix the responsibility on responsible parties.

Now, should the contractor submit designs such as have been referred to, and such as are constantly causing small failures throughout the country, there would be no question as to his responsibility, and the owners would have recourse, but under existing conditions the ordinary contractor, without even as much knowledge as the architect as to the kind of construction that can be safely executed, undertakes the work, and when it fails, it is up to the owners and architects to find means of making it good. We question very much if there is to be any benefit derived from the employment of the ordinary engineer or achitect who claims to be informed upon these subjects, rather than to let the work to a responsible contractor who can make his guarantees good by bond and his financial responsibility.

However, we recognize the fact that there are a few really capable engineers in this line of work, whose

designs, if properly carried out, will secure good results, but it is also a fact that the bulk of these capable engineers are either in the employment of contractors, or are themselves executing work under contracts. We believe that four-fifths of all the reinforced concrete construction work going on throughout the country that is not designed by the contractors, or those in their employment, is being designed by the class of engineers and architects who have practically no knowledge of the business, no valuable experience, and no financial responsibility, and who are putting up a great deal of work that either fails entirely, or would fail if it were tested to anything in the neighborhood of the supposed breaking capacity. I would suggest to the owner who is not willing to take the guarantee of a financially reliable and experienced contractor, that he must closely look and investigate further than the letter head and the sign over the door, if he would succeed in his efforts to employ an engineer to design and supervise his work with the expectation of securing better and surer results. However, all that I have said is not more applicable to concrete construction work than to other kinds of construction.

Very truly,

C. L. Bartlett.

Cedar Rapids, Iowa, Dec. 4, 1906.

Sir: Referring to your report on collapse of the Bixby Hotel at Long Beach, Cal., the collapse of a reinforced concrete building at Kodak Park, Rochester, N. Y., and also the collapse of one floor of a reinforced concrete building in North Milwaukee, all of the same type of construction, it may not be amiss to bring up for discussion the question of the cause of these failures, for the reason that every failure in reinforced concrete is a detriment to those engaged in it, notwithstanding the fact that reinforced concrete buildings, in general, exceed in strength what we figure them, and that nearly all failures occur in process of construction.

Take for example the Bixby Hotel; the writer, as an engineer, might not question the safety of a construction put in with good concrete and given a year's time to set; he would not, however, care to assume the responsibility of erecting it for the reason that he would not consider the concrete sufficiently tied together to make a thoroughly safe proposition for the removal of the forms at the usual periods. The splicing of bars, even if well lapped, in a member as important as a beam is not to be encouraged; neither, in the writer's judgment, should the use of reinforced columns without reinforcement in the shape of lateral ties or hoops, and a very fair percentage of vertical reinforcement, a condition which the writer would not consider to be satisfactorily fulfilled with the bars used. In his own methods of construction, the writer laps the bars by the columns, making the major section of the continuous reinforcement able to take shear, and in the floor panels, wherever practical, reinforcing int two or more directions. Failure of such panels would take place more like the sagging of an old basket. They would sag, for example, a foot or fifteen inches, stretch some of the steel, and then carry a largely increased load before the slab would assume a new catenary in form.

Another question which enters into reinforced concrete construction is that of the rapidity with which the cement hardens. Cold retards its setting. Comparatively few workmen realize this fact and many contractors are entirely heedless of it. The writer has had some trouble of his own on this score. A contractor on one job, while faithfully promising to heat the materials, put in concrete mixed with cold water and comparatively cold materials. The concrete was placed in December, froze up, and stayed frozen until March, when it thawed out, and was almost as soft as the day it was put in. The writer directed that the centering remain in place until the following May. By treating this concrete with water, we secured a material which is fairly satisfactory. Had the centering been removed on this piece of work, there would certainly have been a worse smash than that recorded in the Bixby Hotel. Properly treating the concrete and realizing the nature of the process of setting is one of the requisites of success in the line of reinforced concrete. In all cases in cold weather, before removing the forms, the concrete should be carefully examined to see whether it has set or simply frozen. If a sample piece commences to sweat when placed in a warm room, it is fair evidence that it is unsafe to remove the forms.

The following is perhaps a possible explanation of trouble in handling concrete where the conditions are favorable as regards heat. In Winnipeg, last summer, we found that crushed stone, lying in the sun on the sidewalk, absorbed so much heat that it would cause the cement to partially set before we could get the concrete in place, and that thorough wetting down of the stone pile was necessary before the mixture would work properly.

In working with tile, under conditions where the tile becomes heated by continued exposure in the sun, unless similarly treated, the concrete might be too rapidly dried out and fail to properly crystallize and harden. For that reason, similar precautions should be taken in handling the work. Thus, it is essential to handle the materials intelligently, whether in hot or cold weather.

Another feature to which attention should be called is the combined use of tile and reinforced concrete. It is a fair statement that 90% of the so-called reinforced concrete failures are due to the following improper use of this combination. Where tile is used with reinforced concrete, the tile absorbs the water from the mixture quite rapidly, causing it to appear apparently hard in a shorter time than where the whole mass of the slab is concrete. Hence, the constructor is apt to remove the centers earlier than where the construction is concrete throughout, taking great chances as far as the safety of the construction or the men engaged on it are concerned. Again, this combination does not possess the strength of the all-concrete type, and while it is satisfactory for light construction, when thoroughly set, it probably possesses, in reality, less strength, and is less reliable than the lightest work put up with reinforced concrete throughout. While the writer maintains that there is no better type of construction than reinforced concrete, properly handled and honestly executed, we must consider the characteristics of the material if we are to meet with success in this line of work, just as we do with steel, timber or any other type of construction.

As to the editorial remarks, recalling to your readers the "palmy days of highway bridge building, the days when the collaboration of county commissioners, bridge agents and pools, with careful exclusion of the consulting engineer, resulted in the erection of a merry lot of spider-web highway bridges all over the country," the writer has not observed that these days have, in any wise, ended, and the reinforced concrete business of to-day, as handled by some architects in designing by the "by guess and by God" method employed in the early days of highway bridges, is too frequently followed. For example, a case that the writer heard of through a fellow engineer connected with an iron company, was that of an architect ordering ⅝-in. round rods for the reinforcement of a slab and after he got them on the job, they looked rather large, and he wanted to know if he could not change them to $^{5}/_{16}$-in.! The writer has observed cases where the owners are paying 32 cts. per ft. for reinforcement designed by their architects for a building in which 13 cts. worth of steel would have fully developed the strength of the concrete. While these radical examples would, of course, meet with general criticism, what shall we say of the author of a standard text-book who publishes a column formula suggesting a single round rod in the center of a concrete column as being suitable for scientific reinforcement, or again, what shall we say of the man who rushes into print with formulas for figuring slabs that will not test within 300% to 500% of the strength which properly executed work will develop, the objection to these incorrect formulas lying largely along the line of the encouragement of inferior, unscientific and even unsafe types of design.

It seems to the writer that as the early work in reinforced concrete naturally reflects or imitates methods adopted in other types of construction, such as timber or steel, those who have made a business of writing treatises on concrete have tried to adapt theories applicable to timber and steel types of construction directly to concrete and that eight-tenths of these authors have never personally erected a structure and have had actually no practical experience in the line in which they set themselves up as authorities. The business of construction in this line, in the writer's judgment, cannot be learned by sitting in an easy chair, reading treatises upon it, and discussing it from the mathematical standpoint without definite knowledge as to the accuracy of the assumptions upon which the mathematical discussions are based. One must be familiar with putting in the work and every condition which is met in actually handling it, nor should he expect the uninitiated workman to assume the responsibility, which is frequently thrown upon him, as to the time suitable for removing the centering, and other questions of like importance.

In your editorial, you make the statement that the gray of our concrete structures is already too much stained with blood. That there have been unfortunate errors of judgment resulting in loss of life, the writer does not gainsay, and the example you illustrate of the Bixby Hotel is a most unfortunate one. On the other hand, your statements by inference can be taken to mean that, with other types of construction, there is not the same chance for negligence and loss of life in executing the work. This is a point to which, if the inference is well grounded, the writer wishes to take pointed exception. In his experience as an engineer in the design of steel structures, he will say that somewhere between a half-dozen and a dozen men have lost their lives on the various buildings or bridges that he has designed, and that in no case was anything left undone on the part of the designer to make the execution of the work safe for these men.

We come now to the question of comparative risk in the erection of steel skeletons and of concrete work. While loss of life has occurred in putting up structures that the writer has designed in steel, not a single case of accident has occurred on the numerous structures put up in reinforced concrete that the writer has designed. This is due to the fact, as one of the workmen who has been employed on both kinds of construction put it: "In the erection of a concrete structure, you always had a floor to stand on and were not working on a grid-iron of steel many feet from the ground" and perhaps coated with frost, as it would be in the winter season.

As regards failures, outside of those like the Bixby Hotel which occur during the erection of the work, in which class of accidents can be eliminated by the exercise of greater conservatism in design, providing partially for the weaker condition of the concrete at the time of removal of the forms, and a higher degree of intelligence in handling the work, I think the editor will agree that it is hard to find even a single record of failure of a reinforced concrete building that has stood for a period of six months after the work was placed, for the evident reason that the concrete is increasing in strength as the process of hardening goes on, for months and years, while with other types of construction, the materials are deteriorating rather than improving.

There are unfortunately many reckless contractors as well as designers who will try to break into this new line of business without experience and without securing competent advice. It would perhaps be for the benefit of the industry if those who are allowed to execute the work should be compelled by law to secure a license before being allowed to take charge of the execution or design of a piece of work, and that such licenses should be issued only upon the satisfactory showing of the applicant, as to his engineering ability and practical experience in this line of work. There are, of course, many difficulties in the way of treating all justly under such requirements, but it would seem that the public safety would warrant some regulation.

Very truly yours,

C. A. P. Turner,
President, N. W. Cement Products Assn.

816 Phoenix Bldg., Minneapolis, Minn., Dec. 3, 1906.

Sir: Under the title of "The Lesson from Recent Failures of Reinforced Concrete Structures," you go to some length in condemning the present method of constructing work in this line. You commence with the statement that "Carelessness, incompetence and unscrupulous skinning appear to have almost reached the limit in reinforced concrete construction." You continue by comparing the conditions with those which existed in the highway bridge business some years ago. Further on in the article referred to, you make the following statement: "And nothing is better established in construction work than that contractor and contractee are necessarily opposed interests, in whose contest for advantage there are required, to conserve fairly the interest of both, not only the voluminous provisions of contract law, but also the watchful eye and directing work of an impartial referee, the engineer."

In a general way all of the above statements may contain some substance of truth and even fairness; but in some particular cases which have been the direct cause of bringing forth this article, all of the above intimations and accusations are without any substance of truthfulness, and do not apply in any particular whatsoever.

One of the accidents which happened recently, and which contributed to inspiring the article above referred to, occurred on some work which was being done for the owners on a percentage basis. When work is done for the owner under such an arrangement, there is certainly no chance of the owner and the contractor having "necessarily opposed interests," and there is certainly no need to invoke the "voluminous provisions of contract law," nor the "watchful eye and directing work of an impartial referee, the engineer."

In the case in question, the owner purchased the material, the contractor furnishing him with all possible assistance in this respect, and the benefit of his experience as well. There was surely no object to be gained by the purchase of the inferior material. The materials were inspected not alone by the contractor's employees, but by the engineers and inspectors retained by the owner. As to "unscrupulous skinning," there was not the least inducement for any skinning at all, either in design, materials or workmanship. The contractor was to receive his percentage on the total cost of the work and, in return for his percentage paid as profits, the contractor to assume all the risk from any cause whatsoever on this work. Does it appear reasonable that under these conditions a contractor would voluntarily endanger not only his reputation but his money as well, by skinning down the design or by sanctioning the use of inferior materials, or by permitting carelessness on the work? The accusation of carelessness and incompetence on this particular work must be combated in all fairness. Carelessness may have existed, and incompetence may have existed, but if so, the contractor had no inducement from a money standpoint or otherwise to tolerate either condition.

The salaries and expenses of all employees on the work were paid by the owner. It was only necessary for the contractor to pick out or engage such men as seemed best suited for the work and send them to the job. Their salaries and expenses were borne as before stated, by the owner. Under these conditions, why should the contractor wilfully select careless and incompetent help? Would it not be more natural that he should feel from every standpoint the desirability of selecting the best talent possible, even regardless of price in order that his own risk assumed under his contract should be as light as possible? I do not believe it possible that contract work will ever receive more careful inspection both from contractors and the owners than did this particular work which I am referring to herein. The owners had their own inspectors on the work constantly, while any operations were in progress. In addition to their inspectors they had several engineers who spent their entire time in general supervision of the contractor's operations. The "watchful eye" was not lacking in this case at all; in fact, it was as prominent as a searchlight on the night boats along the Hudson; but the result after all the care that was taken, has been a disastrous failure with a list of dead and injured.

The writer does not believe that you are acting fairly when you rush into print with the explosions of some excited editorial mind in regard to a matter about which he evidently knew nothing, but guessed much. Criticism is but natural in the case of a deplorable wreck costing human lives, no matter what conditions may pertain to the work in question. There must be a cause for any accident; but should not this cause be sought for in a sane, cool, common-sense manner, and without making hasty and absolutely misleading conclusions? There are many possible causes of the particular failure which the writer has above referred to, but it is doubtful if any man or body of men can single out one particular cause from the rest and assert with any degree of confidence, that the accident and resulting casualties were altogether due to that cause. This much, however, we can assert, that the accident was not caused from any of the following reasons:

FIRST: The system used, which has been tried under most severe conditions, and so far as the system is concerned, was severely tried in this particular accident, as tons of material falling from the roof to the next floor below did not damage the floor in any way whatsoever. As a system of reinforced concrete the concurrent opinion of the engineer and architects would agree as to the merits of the particular system used.

SECOND: No skinning of designs would have benefited the contractor in the least, and certainly would not have been desired by the owner, as no motive existed for skinning the construction. Then we believe it safe to eliminate this as a contributory cause of the accident.

THIRD: Carelessness and incompetence no doubt sometimes masquerade in the guise of well-paid and well-recommended men. But no contractor would find it to his interest to gamble his own money on the work done by careless and incompetent men, at any rate when the owner is paying the salary account.

FOURTH: This accident could surely not have occurred from lack of engineering supervision. The owners, engineers and inspectors were very much in evidence on all the work and at all times. Their orders were law, and I think that "lack of the watchful eye" must be eliminated as a cause of this accident.

I consider that all of the above causes of this accident might be eliminated, and if so, then your article above referred to might also be eliminated.

It is difficult to imagine that a contractor could be so hare-brained, so blind to his own money interests, even though he might be indifferent to death and disaster to his workmen, as to deliberately go ahead and employ careless and incompetent help, when good assistance would cost him no more, knowing that if through carelessness or incompetent help an accident should result, his profits would be swallowed up ten times over. It is difficult to see why a contractor should do these things or why he should prefer to skin down designs or use poor materials or poor work, when any or all of these things would endanger many times the amount of his profits, and not add one penny to his income, even though no accident resulted.

In the spasm of hysterics which evidently followed several accidents to reinforced concrete construction recently, we think you have gone beyond the mark of sane, safe judgment. Why not grow a little more hysterical over the deaths which are occurring almost every day in the Belmont and other tunnels about New York City? Why not hold up these engineering enterprises as stained with blood? We will agree that reinforced concrete construction can no doubt be made safer, as experience with its dearly-bought lessons show the way; but we trust that you will not use the columns of the Engineering News to boldly assert that contractors are so indifferent to human life as well as to their own money interests in actual cash, as to be indifferent to possible accidents or failures in this line of work. One failure will cost more than the profit to be made on many buildings of ordinary size. And assume, if you will, that contractors are bloodthirsty, reckless murderers, at least you have given them credit in your article for being alive to the value of the dollar. If so, no contractor of sound mind would take any chances of having an accident, if human skill could avoid it.

Yours very truly,

F. E. Webber.

1 Madison Ave., New York City, Dec. 6, 1906.

We might take much space for replying to some statements in the above letter, but we shall content ourselves with a hysterical reference to Mr. John B. Leonard's report on the Bixby Hotel failure on p. 599 of our last issue. Mr. Leonard there stated that computation showed compression stresses in the concrete columns of 750 lbs. to 1,100 lbs. per sq. in. To show the significance of these figures, we make a quotation from a paper on concrete construction by a high authority which is to appear in our next week's issue.

> Don't stress your concrete in compression higher than 300 lbs. per sq. in. (mixture 1:2:3) in beams, columns or arch-work, unless you are going to have first-class inspection. 400 lbs. per sq. in. is high enough when the work is going to receive the best class of inspection.

Notes and Queries.

Mr. G. E. Johnston, Louisville, Ky., writes:

Can you or your readers furnish some information in regard to force or "suction," caused by a moving train tending to draw bodies under the train? The question has been brought before me, and on looking into it, I find no data on the subject as far as I have searched up to this time, though there are several works that approach it more or less, but when it comes to actually treating of the force in the direction mentioned, they do not do it.

We do not see how it would be possible to give any absolute values for this force since it would vary with variations in conditions such as the force and direction of the wind, the state of the barometer, and most of all with the position where the measurement was taken.

H. L. R., Louisville, Ky., writes:

We have prospective work in reinforced concrete, the building of a distillery, in which there are proposed to be built several mash tubs of concrete. These tubs are to be 19 ft. in diameter and 6 ft. deep. The maximum temperature, which is reached in a short space of time, is 212°. The information we desire to obtain is:

1.—Can these tubs be reinforced and overcome the expansion satisfactorily?

2.—If the tubs are built in the ground would any advantage be gained?

3.—Can they be built of monolithic concrete if built in the ground?

4.—Will the concrete tubs taint the mash after they have been thoroughly cleansed many times?

See "Reinforced Concrete" by Buel and Hill, 2d. ed., Engineering News Pub. Co., 1906; Chap. X. on "Examples of reinforced tank and reservoir construction." It is probable that a tub built in the ground would hold its heat a longer time than if exposed, and would be less likely to give trouble from temperature cracks in severe winter weather. We see no reason why concrete would taint the mash more than would steel, stone or any other material out of which the tub might be built.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS AT NEW YORK CITY.

The American Society of Mechanical Engineers held its annual meeting on Dec. 4 to 7 at New York City, but not in the Engineering Building as had been announced two months ago. The courtesy of the New York Edison Co. gave the society the use of the assembly rooms in the company's substation at 44 West 27th St., while the annual reception was, as usual, held at Sherry's.

The meeting was opened on Tuesday evening, Dec. 4, by a general session (or "social reunion," in the vernacular of the society's announcements), at which the Presidential Address of retiring President Frederick W. Taylor was read. Four professional sessions followed, respectively Wednesday morning, afternoon and evening and Thursday morning, bringing the final adjournment on Thursday noon. Thursday afternoon the New York Central & Hudson River R. R. took the members of the society on a special train over the electric portion of its terminal lines to its Port Morris power station. The annual reception was held on the evening of the same day. Friday was given up in its entirety to what was probably the most noteworthy trip that the society has made in recent years—a visit to the Sandy Hook (N. J.) Proving Grounds and the coast defence fortifications on the Hook, under the guidance of Brigadier-General Arthur Murray, Chief of Staff; Brigadier-General William Crozier, Chief of Ordnance; Colonel Charles .S. Smith, Commander, and other officers. The large party of visitors enjoyed a half day's tramp through sand, sharp winter cold and a gale of wind, inspecting coast defence guns, targets, range-finders and the like, and watching gun-fire in various calibers from 10-in. shell fire from guns and mortars down to one-pounder subcaliber firing in the 12-in. disappearing rifles of Fort Hancock. Half a dozen foreigners with the party were personally conducted by an officer detailed for the purpose and were shown special courtesies in the comfortable Headquarters while the citizen visitors made their chilly trip through the fortifications.

The society business transacted at the meeting was unusually small in amount. Two amendments to the constitution, which will be voted on during the coming year, were called up, but neither discussion nor amendment was offered. One of these amendments is of very general interest, as it adds a Research Committee to the list of standing committees of the society, and if passed will thereby introduce a new and permanently important feature into the society's professional activity. The other amendment aims to create the post of Honorary Secretary, and provides for filling it by appointment of the Council, once each year. The annual report of the Council was also passed over without discussion.

The count of the ballot for election of officers for the coming year gave the following result: President, Prof. F. R. Hutton (New York, N. Y.); Vice-Presidents, John W. Lieb (New York, N. Y), P. W. Gates (Chicago, Ill.) and Alex. Dow (Detroit, Mich.); Managers, A. J. Caldwell (Bridgeport, Conn.), G. M. Basford (New York, N. Y.) and A. L. Riker (Bridgeport, Conn.); Treasurer, Wm. H. Wiley (New York, N. Y.). It is of interest to note that the ballot for President Hutton was the largest ever cast for a President in the Society's history.

TECHNICAL PROCEEDINGS.

In reviewing the professional work of the meeting, we must place at the head in importance as well as in time the monumental Presidential Address of Mr. F. W. Taylor (Philadelphia, Pa.), "The Art of Cutting Metals," a document which easily overshadows any paper read before the Society in years, possibly in its entire life, and which will rank as a classic of engineering. Last week we reprinted the first or general half of the address, and in a later issue we shall print an abstract of the second or detailed part. The discussion of the address was voluminous; a dozen or more contributors submitted detailed written comment and an equal number discussed it orally. It happens that the nature of the comment, quite aside from our own limitations of space, makes it impossible to reproduce its substance here. Only a few brief notes can be given.

Mr. Daniel Adamson (Hyde, Cheshire, Eng.), a member of the Manchester Committee on Tool Steel, wrote in defense of adopting the area of cut as a fundamental variable (which was done in the Manchester experiments) rather than considering depth of cut and feed to be independent variables as regards the influence on permissible cutting speed and life of tool. He believes that Taylor's tables show the area-of-cut method to be not more than 8% or 10% in error at the worst. Certain other points of comparison between the Manchester work and Taylor's investigations were cited, with argument for the Manchester methods, among them the use of a revolution counter to compute cutting speed, in conjunction with the mean diameter before and after cutting. Mr. Adamson also raised question concerning the effect of some factors not discussed by Mr. Taylor: the use of tool-holders in place of solid forged tools, and their suitability; the height of tool-point above lathe-centers; the difference between acid and basic steel as concerns ability to cut them at given speed, and the difference between mild steel and wrought iron in the same respect.

Vickers Sons & Maxim (Sheffield, Eng.) also upheld the principle that area of cut is a basal

factor rather than feed and cut independently, arguing that if the point of tool in Mr. Taylor's experiments had been differently ground so as to turn a chip of similar shape in the two cases, the speed and life of the tool would probably have proved to be the same for ⅛-in. cut with ⅛-in. feed as for ½-in. cut with 1/32-in. feed. They find that the permissible speed increases as the diameter decreases, possibly due to change of angle of surface. The shape of cross-section of the tool is an important question; they believe it should be square, to have equal strength against cutting pressure and feeding pressure.

Mr. F. M. Osborne (Samuel Osborne & Co., Sheffield, Eng.) recounted briefly Mushet's discovery of air-hardening steel and its development, with the later discovery of Gladwin that a blast of air during cooling increases the hardness. He characterized the Taylor-White invention as that of a process, not a material.

Prof. J. T. Nicolson (Manchester, Eng.) strongly defended the scientific character of the Manchester experiments, and incidentally the area-of-cut principle. Mr. H. C. H. Carpenter (Manchester, Eng.) discussed the chemical characteristics of steels, with regard to "red-hardness," and asserted that carbon can no longer be considered the sole hardener. On a metallographic basis he made a division of tool steel into three classes—carbon, Mushet and high-speed. M. Codron (Lille, France) reported that his experiments show tool pressure to increase with cutting speed, instead of the inverse that Mr. Taylor finds. The same law holds for boring, punching, etc. The general average curves given by Mr. Taylor agree well with those he has found. The first part of his experimental results will soon be published. Mr. H. L. Gantt (Pawtucket, R. I.) gave special emphasis to the Taylor system of task management as being a more important development than the investigations of metal-cutting. He asserted that in 26 years not one exception has been found to the applicability of the basal principle of the system, viz., that a larger amount and more efficient work will be done by any man when his work is directed in detail by another man than when he himself governs the doing of it (as in both day work and piece work). But in reference to this same phase of the subject Mr. J. T. Hawkins (Boston, Mass.) complained that the Taylor system would eliminate the skilled mechanic, the "fingerwise" man, and that this might prove disastrous. This view was strongly combated by Mr. Taylor, who asserted that the system produces more skilful mechanics than any other, in its foremen, bosses and inspectors.

There was a good deal of concrete comment other than that indicated above, and no lack of appreciative remarks. Mr. H. R. Towne (New York, N. Y.) even classed the results presented in the paper with the invention of the sewing-machine and the typewriter, in their importance to the human race and in their character of putting a world-old art (sewing, writing, metal-working, respectively) on a scientific basis of greatly increased efficiency.

The first paper following the presidential address was "The Evolution of Gas Power," by Mr. F. E. Junge, a historical and analytical study of gas engines and producers. In discussion, Prof. R. C. Carpenter (Ithaca, N. Y.) gave a brief statement of the work of Geo. B. Brayton, inventor of the Brayton cycle for gas engines. Mr. W. D. Ennis (Oneonta, N. Y.) stated that the author's views are too favorable to the gas engine, as in America at least the higher cost of the gas engine compared with the steam engine is very appreciable, and neither producer nor engine efficiencies are as high as the author claims, while, on the other hand, there is a distinct possibility of raising steam engine efficiencies up to those claimed for gas engines.

Mr. R. E. Hellmund expressed the hope that better results might in the future be obtained with driving electric generators by gas engines than have been obtained hitherto. Mr. J. E. Johnson, Jr. (Longdale, Pa.), suggested the transmission of gas at a delivery pressure suitable for direct discharge into Diesel engines, as an improvement on electric transmission. He also asserted that blast-furnace practice will never reach the point where the iron is a mere by-product of gas manufacture, and further pointed out that gas engines should be compared with high-grade steam engines rather than with the inefficient blast-furnace auxiliaries hitherto used.

Prof. R. H. Fernald (St. Louis, Mo.) presented in the form of curves some results of the Government gas-producer tests of coals, with relation to the calorific value of the coal. Mr. R. E. Mathot stated briefly some points of present-day European gas-engine practice: higher compression, combustion chambers of better form, better designs of water-cooled pistons, lower price of gas engines, abandonment of variable ignition, etc.

Prof. C. E. Lucke (New York, N. Y.) took the view that the author is too favorable to gas engines, and suggested some of the points of imperfection still to be improved. Designing gas engines specially to suit the individual case was put forward as a necessary future development. The many contract failures of gas engines in this country he described as a deplorable thing, due partly to the buyers and partly to the manufacturers.

Mr. J. R. Bibbins (E. Pittsburg, Pa.) followed with a paper entitled "The Operation, Efficiency and Construction of a Modern Producer-Gas Power Plant," describing the power plant which serves the Gould Coupler Co. and the Gould Storage Battery Co., at Depew, N. Y. This paper is reprinted in abstract elsewhere in this issue.

Under the title "Steam Turbine Characteristics," Mr. H. Holzwarth (Hamilton, Ohio) presented a method of studying steam turbine actions, using logarithmic P V diagrams and a diagram invented by Prof. Mollier, of Berlin. The paper was briefly discussed in a letter by Capt. H. R. Sankey (London), who suggested still another form of diagram and advocated the term "efficiency ratio" in place of "total efficiency."

Steam boilers were the subject of two papers, one by Mr. A. Bement (Chicago, Ill.) on "An Improved Boiler Setting"; the other by Prof. R. C. Carpenter (Ithaca, N. Y.) on "The Steam Plant of the White Motor Car." The former paper described a design of furnace and setting for boilers of the horizontal water-tube type in which (1) the furnace has a roof of tiles set around and between the lower row of tubes, these tubes being made 3-in. instead of 4-in. to give more room for the tiles; (2) the vertical baffles among the tubes are spaced closer together, and so as to give decreased area of passage toward the stack. The tile roof, extending as far back as possible, has the purpose of ensuring complete or "smokeproof" combustion, while the arrangement of the baffles is designed for full utilization of the heating surface. Prof. E. A. Hitchcock (Columbus, O.) criticized the particular tile roof employed, as reducing the capacity of the furnace. Mr. W. H. Bryan (St. Louis, Mo.) stated that neither the tile roof nor the reduced passages are novel, and cited old designs and patents of the former. The combination of induced and forced draft referred to in the paper as "balanced draft" he described as valuable but not new. This system was further discussion, for and against, by several other speakers.

Prof. L. P. Breckinridge (Urbana, Ill.) confirmed the author's claims for the tile-roof furnace with chain-grate stoker for smokeless and economical combustion of Western bituminous coals. He pointedly criticized the inactive attitude of boiler builders toward questions of furnace construction and setting, and suggested that it is their proper function to design and sell boiler, furnace and stoker together. The St. Louis experiments will probably yield valuable information as to proper height and length of combustion chamber with various coals. Mr. W. D. Ennis (Oneonta, N. Y.) remarked on the frequency of bad proportioning of the gas passages in boilers, especially water-tube, and cited a concrete case.

Prof. Wm. Kent (Syracuse, N. Y.) approved the author's design, but suggested that, in common with other smokeless-combustion arrangements, it should have a means for increasing the air supply at rates of combustion above normal. He criticized the author's statements in favor of "balanced draft," as they were based on cases of very poor boiler working.

Mr. W. L. Abbott (Chicago, Ill.) took a position like Prof. Breckinridge's in approving the author's recommendations as logically necessary for Western coals, and in criticizing the attitude of boiler manufacturers. Prof. D. S. Jacobus (Hoboken, N. J.) on the contrary claimed that the Babcock & Wilcox design of furnace and setting for long-flaming Western coals is better for the purpose than the author's.

Prof. Carpenter's paper on the power system of the White steam car, which comprises a single-tube boiler heated by gasoline and a compound engine 3 and 6 ins. × 4½ ins., described brake tests made on the apparatus used as a stationary plant and running non-condensing. The test runs were ½ hr. to 2 hrs. long. The steam-consumption at full-load and overload, at 850 r. p. m, was very close to 12 lbs. per B. HP.-hr. The evaporation was 11.5 lbs. water actual, or 13 lbs. from and at 212° F., per pound of gasolene (sp. gr. 0.705 at 60° F.). The boiler pressure averaged 595 lbs. per sq. in., the boiler superheat about 300° F. An interesting feature of the paper is that it gives for the first time the results of an extended investigation of the specific heat of superheated steam.

Prof. C. C. Thomas, in a communicated discussion, described the apparatus and methods used in this investigation. In discussion of the paper itself, Mr. Warren S. Johnson remarked that while the White steam plant is under complete automatic control when in use on a motor-car, the test did not employ automatic control; further, that as the engine is in no wise novel, the test is virtually one of the boiler only. He himself published the result, several years ago, that a single-tube boiler will evaporate 15 lbs. water per pound of gasolene, a result which agrees with that of the author.

A paper on "A High-Duty Air Compressor," by Prof. O. P. Hood (Houghton, Mich.) gave the result of tests of a Nordberg quadruple-expansion two-stage air compressor at the mine of the Champion Copper Co., Painesville, Mich. The engine has steam cylinders 14½, 22, 38 and 54 ins. by 48 ins. stroke, and air cylinders 23.02, 23.07, 36.74 and 37.22 ins. diameter in tandem with the steam cylinders. A five-stage feed-water heater is provided, the heating medium being: (1) exhaust steam, (2) steam abstracted from the low-pressure cylinder during expansion by a special valve, (3) the discharge from the low-pressure jacket which in turn was fed from the third receiver, (4) the discharge from the second intermediate jacket (supplied from the second receiver), plus the discharge from the reheaters (which are supplied in series by the high-pressure jacket), and (5) steam from the first intermediate jacket which is itself supplied from the first receiver. The engine was designed for 300 lbs., but the boilers could furnish only 250 lbs. pressure. The engine developed a duty of 194,300,000 ft.-lbs. per million B. t. u. supplied to the engine (deducting feed returns), a new low record. Its actual heat efficiency was 25.05%.

Mr. Geo. H. Barrus (Boston, Mass.) criticized various details of the test and the records presented, and questioned whether the results demonstrate the superiority of this complex engine system over an ordinary triple-expansion engine, provided the latter were operated at the same boiler pressure, 250 lbs. per sq. in. He also raised the question whether the economizer was of any material service when the engine supplied it with water already heated to 335°, a question which the test records do not answer. Criticism was made by several of the compressor part of the test, but this is only an incidental feature of the paper. Mr. W. L. Saunders (New York, N. Y.) asserted that a better, or at least as good, engine performance was found by Barrus in testing a Cooper Corliss engine at the Atlantic Mills, and that therefore the paper does not justify the great complication of the engine as compared with the simplicity of the two-cylinder compound. Prof. D. S. Jacobus (Hoboken, N. J.) suggested that errors in the indicator spring values might

be contained in the results, especially as the engine friction, about 10%, seemed unusually high.

Much discussion was aroused by a paper entitled "A Plan to Provide Skilled Workmen," by Mr. W. M. Alexander. The author described the apprenticeship system which has been developed at the works of the General Electric Co., at West Lynn, Mass. This comprises a two-year period in a training room separate from the shop but fully equipped and under expert foremen and instructors, and a two-year course in the regular shop, combined with a special school for elementary and practical courses in sciences, etc., occupying part of the regular working time. The discussion of the paper was chiefly noteworthy for the unanimity of belief in the crying need of the present day for better apprenticeship methods, and for the diversity of view as to the proper means and methods to be used.

Mr. Howard A. Carson (Boston, Mass.) presented a paper entitled "The Ventilation of the Boston Subway," a brief description of the ventilating system. We expect to give an abstract of this paper in a future issue, so that a statement of the contents of the paper here is unnecessary. Prof. S. H. Woodbridge (Boston, Mass.) in a letter discussing the paper showed the inferiority of a method which had been proposed when the ventilating scheme was being worked out: supplying air to the subway at numerous points from an airway alongside, this airway being supplied with outside air by a blower midway between stations. He then gave in tabular form the results of tests of four fan blowers, of different types, a 36-in. cased radial, a 36-in. uncased radial (both with straight blades), a 36-in. Briggs-Meigs radial (with curved blades and contracted peripheral openings, and a 30-in. axial fan. The latter is the only one which showed a decreased power-consumption with increased delivery, all the others requiring increased power as the discharge increased. The axial fan, moreover, required by far the lowest amount of work per cubic foot of air moved. As the function of the fans to be used for the ventilating was to move air in quantity at minimum power consumption, against very low pressures, the axial fan was held to be the proper choice.

Mr. C. S. Churchill referred to the ventilating equipment of the Boston Subway as being not excelled anywhere. The arrangement used in the East Boston Tunnel of the subway is similar to that used in the Mersey Tunnel at Liverpool, except that the latter has the air-duct wholly outside the tunnel section, while in the former the upper part of the tunnel is cut off by a partition to form the air-duct. He suggested that it would be practicable to ventilate the East Boston Tunnel by blowing in air at one end and forcing it through the whole length of the tunnel.

Mr. Wm. Clifford advocated controlling the fan-motors in such a way as to maintain constant volume of discharge, varying the pressure to oppose the effect of the piston action of trains. In his experiments with a fan at the center of the Hoosac Tunnel he had found the pressure to vary from 0.36 to 0.8-in. water due to this action. Mr. Francis Fox suggested that the ventilation of the cars in a subway needs as much attention as the ventilation of the subway itself. Mr. T. Weinshank took issue with Prof. Woodbridge on type of fan used, and claimed that the disk fan would fail on increased demand.

Tests of the Venturi meter for measuring steam and air were reported in a paper entitled "The Flow of Fluids in a Venturi Tube," by Mr. E. P. Coleman (Buffalo, N. Y.). The author's erroneous use of "Venturi tube" for "Venturi meter" is coupled with an error in attributing the invention and study of the Venturi meter to Venturi in 1791, whereas in fact the device was invented by Clemens Herschel 96 years later. The author's experiments with steam were made at throat velocities of 572 and 208 ft. per sec., with 99.5% steam at 110 lbs. pressure. The quantity flowing was determined by weighing the feed-water pumped to a group of boilers whose discharge passed through the Venturi meter. The errors in the two measurements were + 0.056 and — 0.84%. The author suggests that steam containing more moisture would give less accurate results. These tests were made with a 6-in. meter. A 6-in. and a 10-in. meter were tested on air at about 9-oz. pressure above atmospheric. Here the readings were compared with Pitot-tube readings. The throat velocities were 166.2, 192.9, 242.2, and 197.16 ft. per sec. respectively, and the error of the Venturi referred to the discharge computed from the Pitot-tube readings, was — 0.0078, — 0.0037, — 0.0025, and — 0.0024 respectively.

In discussion Mr. S. A. Moss (Lynn, Mass.) stated that he has for some time used a Venturi meter for compressed air, and his calibrations, based on the discharge through a calibrated orifice, gave results of the same order as the author's. Mr. Clemens Herschel (New York, N. Y.) after pointing out the error mentioned above, said that the author's experiments are the only recorded tests of the Venturi meter with gases, and form almost the first case where the meter has been used for gases; the American Water Improvement Co., of Philadelphia, is using the Venturi meter for measuring ozonized air fed to water-purification apparatus. He noted the fact that Pitot-tube measurements are by no means more accurate than those made by Venturi meter, and the latter should therefore not be calibrated by the former but by gas-holder measurement.

Prof. A. L. Williston (New York, N. Y.) reported that in comparative measurements of flow of air, which he made some years ago, by Venturi meter, Pitot-tube, current meter, orifices, etc., he found that the Venturi meter gave results within 1% of those obtained from orifices, provided the difference of pressure could be measured with accuracy. The weakness of the device lies in its unsuitability to large ranges of velocities; that is, its inability to give accurate results on low velocity. The author remarked that for this case a device like the Sargent spiral might be used, to give accurate readings of low heads.

A noteworthy result was presented by Prof. W. B. Gregory (New Orleans, La.) in a paper entitled "Test of a Rotary Pump." A pump forming the irrigation plant of the Abbeville Canal Co., located near Abbeville, La., was tested in 1905; lifting 15.5 ft. and discharging an average of 72.13 cu. ft. per sec., it had a combined efficiency of pump and engine of 81.77%. A four-unit pumping plant of the Neches Canal Co., near Beaumont, Tex., was tested in 1906. This plant comprises two boilers furnishing steam to four tandem compound condensing Hamilton-Corliss engines 18 and 36 × 48 ins. each, coupled to a rotary pump by way of a babbitt key coupling.

The pump is a two-lobed cycloidal rotary, 39 ins. pitch diameter, 58½ ins. long, with a displacement of 605 gallons per revolution. Two tests were made, one covering two of the units, the other the whole plant. The water pumped was lifted about 32 ft. and was discharged into an open flume, where it was measured by current meter and Pitot-tube, in conjunction with a depth gage. The first day's test showed practically absolute agreement between the flume measurements of pumpage and the displacement of the pumps, and in the second day's test therefore the displacement was used for calculating delivered horsepower.

The combined efficiency of engine and pump in a 6-hr. test on Aug. 8, 1906, averaged 83.28%; the engines were not indicated in the test of Aug. 9. On Aug. 8 the consumption of oil per water-horsepower-hour was 2.084 lbs., and on Aug. 9 it was 1.892 lbs.; the oil had a calorific value of 18,790 B. t. u. per lb. The evaporation from and at 212° F. was 13.36 lbs. per pound of oil (Aug. 8). As the oil cost 65 cts. per barrel of 315 lbs., the cost of fuel for raising 1,000,000 gallons of water one foot was 1.81 cts. (Aug. 8) to 1.64 cts. (Aug. 9).

Prof. R. C. Carpenter (Ithaca, N. Y.) questioned the correctness of the test, because of the high efficiency shown. The test would appear to give the pump itself an efficiency of at least 95%. The Pitot-tube measurements for obtaining the discharge may be responsible for some error, a view supported by the agreement of discharge with displacement.

Mr. A. M. Lockett (New Orleans, La.) made the point that with 83% efficiency for the rotary pump and 70% for a centrifugal pump, the extra cost of the former might not be justified in rice-field pumping. He questioned, further, whether the rotary can always deliver its rated capacity with safety, and cited a case where powerful water-hammer occurred at certain speeds in spite of large air-chambers on both suction and discharge. The possibility of foreign bodies, sand, etc., getting into the suction pipe would also argue in favor of the centrifugal pump.

"An Improved Transmission Dynamometer," by Prof. W. F. Durand (Stanford University, Cal.), described a modified form of Tatham belt dynamometer which has been used by the author in propeller experiments. The features are: the use of sprockets and chain in place of pulleys and belt, which eliminates errors due to belt slip; the use of an Emery spring-plate bearing in place of a knife-edge, and the use of ball-bearings for the four pulley spindles, whereby internal friction is minimized; and the arrangement of the weighing arm to permit weighing the torque by spring-balance scales or hydraulic step. The dynamometer is portable and can be used in either direction of running. A dynamometer using 9-in. sprockets with 0.3-in. chain, and with overall dimensions 12 × 30 ins. high, had a capacity up to 10 to 12 HP.

Three papers on Roofs and Roofing were presented, as follows: "Sawtooth Skylights in Factory Roof Construction," by Mr. F. S. Hinds (Boston, Mass.); "Sawtooth Roofs for Factories," by Mr. K. C. Richmond (Providence, R. I.); and "Ferroinclave Roof Construction," by Mr. A. E. Brown (Cleveland, O.). The latter paper recounts the origin of the peculiar dovetailed form of corrugated sheet-metal invented by the author as a central reinforcement for concrete roofing and floor slabs, and further gives tests and data concerning the material. The papers on sawtooth roofs present little or nothing of novelty, but show a good collection of views of sawtooth shop and mill roofs.

The following papers were also read: "Tests of a Plunger Elevator Plant," by Mr. A. J. Herschmann (New York City); "A Mechanical Engineering Index," by Profs. W. W. Bird and A. L. Smith (Worcester, Mass.); "Our Present Weights and Measures and the Metric System," by Mr. H. R. Towne (New York City). The last-mentioned paper gave a review of the situation in this country in the subject of metric agitation, and advocated a technical commission of the Government to study the issues involved in changes of our weights and measurs. An extended discussion followed, which revealed opposition to such a proposal, as well as support. The difficulty of getting men of suitable caliber for such study, and men who would be representative and judicial, was cited against the proposal, while one of the detail points brought up in its favor was the unjudicial and strongly prometric attitude of the Government's present custodian of weights and measures, the Bureau of Standards.

Two reports of technical committees of the Society were to come before the meeting: the report of the Committee on Standards for Small Machine Screws, and that of the Committee on Tests of Refrigerating Machinery. The latter presented a preliminary report, which will shortly be distributed in printed form for comment. The subject of small machine screws is still in the shape in which the Chattanooga meeting (May, 1906) left it; that is to say, the recommendations of the committee are strongly criticized, and the virtue of the fundamental recommendation: the Tyler modification of the Sellers thread, is questioned. No work has been done toward preparing standards for sizes over ¼-in. diameter.

THE HIGHEST PRICE FOR COPPER yet noted was reached Dec. 10, when lake copper advanced $5.00 per ton and both electrolytic and casting, $2.80 per ton. This advance puts the price of lake copper, on the New York market, at 22¾ to 23 cts. a pound, and electrolytic at 22¼ to 22½ cts. The price of lake copper has advanced $110.80 a ton in the past year, and electrolytic $99.60, while casting has advanced $108 per ton in the same period.

THE WORK OF THE INTERNATIONAL WATERWAYS COMMISSION.

By J. A. Macdonald.*

The increasing spirit of fairness which Canada and the United States are manifesting towards each other in the attempt to reach an amicable settlement of all international questions which have arisen or may arise between the two neighboring countries is a hopeful sign. The brief history of the International Waterways Commission shows what has been and can be accomplished where there is a disposition to give due consideration to the rights of both countries concerned as affecting waterways along the international boundary. Last April, practically at the outset of their labors the Commissioners suggested certain principles for their guidance. One of these principles was that "no obstruction or division should be permitted in or upon any navigable water crossing the boundary or in or from streams tributary thereto, which would injuriously affect navigation in either country."

This principle has been applied to two important waterways questions which have recently engaged the attention of the Commission.

One application dealt with was that of the Minnesota Canal & Power Co., of Duluth, for permission to divert waters in the State of Minnesota from the Rainy River which constitutes the boundary between the United States and Canada. The conclusion was, in this case, that,

"while the work proposed by the company would be of great advantage to the interests served, it would interfere with public and private interests in Canada and injuriously affect navigation upon the boundary waters, therefore the permit applied for should not be granted without the concurrence of the Canadian Government."

Another case was that of the International Development Co., a Canadian concern, which sought permission to construct regulating works in the Richelieu River, the purpose being to store up in Lake Champlain during the water season enough of the surplus water to supply a deficiency in the Richelieu River during the low-water season. Lake Champlain being within the territory of the United States and the proposed works wholly within Canadian territory, the international questions raised were of serious moment.

The Waterways Commission has made a report to the Canadian Minister of Public Works, excerpts of which only are here given.

Regarding the regulating works in the Richelieu River referred to, by endorsement of the Secretary of War of the United States, dated Nov. 6, 1906, the report says:

The works are to be located in Canadian territory and can be built only with the authority and approval of the Canadian Government. It is supposed that proper plans will in due season be submitted to that Government. The works will, however, affect the levels of Lake Champlain, and may thus seriously affect the navigation or property interests of American citizens on that lake. The company submits a preliminary statement showing in general what is proposed to be accomplished, and the supposed effect upon Lake Champlain, with a view to ascertain what the attitude of the United States Government will be towards the enterprise, and it is that which has been referred to us.

It is ascertained from this statement that for navigation and power purposes a continuous flow of not less than 9,000 cu. ft. per sec. is desired in the Richelieu River. The average annual flow is greater than this, being about 12,700 cu. ft. per sec. The low water discharge is about 3,800 cu. ft. per sec., and there are periods, sometimes extending over six or eight months, when the discharge is continuously less than 9,000. It is proposed to store up in Lake Champlain during the high water season enough of the surplus water to supply the deficiency during the low water season. For this purpose regulating works are to be constructed in the Richelieu River by which the level of Lake Champlain will be maintained at a minimum of 97 ft. above tide at New York; and it is stated that these works will not under any circumstances raise the high water level of Lake Champlain above "the present high water mark," given at 101.5. Thus it is proposed to give the lake a range of 4.5 ft.

The report of the Board of Engineers upon Deep Waterways between the Great Lakes and the Atlantic tidewaters has a tabular statement of the monthly mean discharge of Lake Champlain for the years 1875 to 1898, inclusive. An examination of this table shows that the period which gave the lowest discharge extended from September, 1882, to March, 1883; the next lowest from September, 1876, to March, 1877; the third lowest, from September, 1883, to February, 1884; and the fourth lowest from August, 1894, to March, 1895. During these periods the amount flowing was less than 9,000 cu. ft. per sec., and in order to maintain that flow it would have been necessary to draw, from water previously stored for the purpose, the difference between 9,000 cu. ft. and the amount which actually flowed.

To again quote from the report:

	Cu. ft.
The deficiencies for the first period were..	58,803,840,000
Those for the second period were.....	55,572,480,000
Those for the third period were.....	51,278,400,000
Those for the fourth period were.....	46,759,680,000

The area of Lake Champlain is 436.7 sq. miles, or 12,174,497,280 sq. ft. The depth required to store the deficiency during the first of the above periods is 4.81 ft.; that for the second period is 4.56 ft.; for the third period it is 4.21 ft., and for the fourth period it is 3.84 ft. Adding 1.25 for evaporation in eight months, those depths become 6.06, 5.81, 5.46 and 5.09 respectively. The range proposed, 4.5 ft., will, therefore, not be sufficient to provide 9,000 cu. ft. per sec. throughout the low water season in very dry years.

A range much greater cannot be admitted without inflicting damage either upon the riparian owners or the navigation interests of Lake Champlain. In determining what is a proper high water and what is a proper low water stage in this connection, it is not fair to take the extremes which the lake may have reached at long intervals in its history. A high water stage reached once in twenty years, for example, might inflict damage to property without destroying it, while if reached every year it might cause complete destruction; likewise the obstruction to navigation caused by an extreme low water stage would be greatly multiplied if repeated every year.

The table of the report on deep waterways quoted above gives the monthly mean stages of Lake Champlain from 1875 to 1898. The highest stage there recorded is 100.13 for the month of April, 1896. Upon only two other occasions did the stage reach 100. To raise the level above 100 regularly every year would be to inflict an injury upon the riparian proprietors.

The mean elevation of the lake for the entire period was 96.10. The lowest reached was 93.65. During seven years it did not fall below 95. To allow the lake to be drained below 95 every year would be to inflict injury upon the navigation interests.

The limits between which the lake should be regulated are, therefore, 100 as a maximum and 95 as a minimum, notwithstanding that the reserve of water will not in very dry years be sufficient to supply 9,000 cu. ft. per sec.

It is manifest, therefore, that the applicants should furnish conclusive evidence that private rights in the States of New York and Vermont adjoining Lake Champlain will not be injuriously affected by the alteration of the lake level as proposed, and that the Secretary of War of the United States has control of the interests of navigation on Lake Champlain, the said work should be operated under such regulations as he may direct with a view to the maintenance of the level of the said lake as the interests of navigation thereon may require. It would be possible to plan works adapted to the conditions, and in our opinion such works should be permitted, provided they do not interfere with private interests in the United States and meet with the approval of the Secretary of War as suggested. We respectfully submit that in any treaty to be had between the two nations in relation to the use of international waters, the principles above suggested should have consideration. We would further suggest that the applicants' Canadian act of incorporation should be amended so as to provide that the maintenance of the works sought to be erected shall be conditional at all times upon compliance with all regulations imposed by the Secretary of War of the United States of America, from time to time, for the preservation of the levels of Lake Champlain.

Following its decision upon this application the Commission made the important recommendation that as questions involving the same principles and difficulties liable to create friction, hostile feelings and reprisals, are liable to arise between the two countries, affecting water on each side of the boundary line, a treaty be entered into which shall settle the rules and principles upon which all such questions may be peacefully and satisfactorily determined as they arise; and further, that any treaty should define the uses to which international waters may be put, as (a) use for necessary domestic and sanitary purposes, (b) service of locks used for navigation purposes, (c) the right to navigate.

The Commission also suggested that the treaty should prohibit the permanent diversion of navigable streams which cross the international boundary or which form a part thereof except upon adjustment of the rights of all parties concerned by a permanent Commission, and with its consent.

With such an evident desire on the part of both countries to treat each other fairly in questions affecting international waterways, it would be an easy matter to negotiate a treaty which would be broad and liberal in its provisions and eminently satisfactory to both Canada and the United States.

In the case of this Commission more good work has been accomplished in a few months and at a trifling cost than could have resulted from years of negotiation through the Colonial Office.

*104 Queen St., Ottawa, Canada.

STATISTICS OF PASSENGER TRAFFIC IN GREATER NEW YORK.

The passenger traffic statistics for the surface, elevated and underground railways of Greater New York are given by the New York Railroad Commission for the quarters ending Sept. 30, 1905, and Sept. 30, 1906, respectively, in a recent report.

The accompanying tables taken from this report are of interest. Table I. shows the relation between the traffic on the surface, elevated and subway lines in the Borough of Manhattan.

From this table it is apparent that the greater increase of traffic is going to the subway and also that car-mileage is keeping pace with the passengers carried only on the subway lines. The surface cars, while carrying practically the same number of people in 1905 as in 1906, decrease their car-mileage 7.2%, while the elevated shows a much greater overcrowding, with a cash-fare increase of 11.1% and car-mileage decrease of 2.3%.

As the report covers the period from July to September, when on account of the extreme heat the subway is the least comfortable of any of the systems, the increase in its use must show the necessity for its existence and its popularity with the people.

Table II. gives the relation in traffic between the systems in the various boroughs:

TABLE II.—TRAFFIC ON VARIOUS STREET RAILWAYS IN GREATER NEW YORK.

Borough.	Cash Fares. 1905.	1906.	Increase.	Percentage Increase.
Manhattan ..	179,185,431	191,027,482	11,842,051	6.6
Brooklyn	105,703,723	113,072,393	7,368,270	7.0
Bronx	7,415,446	9,061,647	1,646,601	22.2
Queens	6,992,069	7,945,129	953,060	13.6
Richmond ...	3,038,841	3,574,473	535,632	17.8
Total ..	302,335,510	324,681,124	22,345,614	7.4

Borough.	Car Mileage. 1905.	1906.	Increase.	Percentage Increase.
Manhattan ..	38,202,835	38,130,463	*72,372	*0.2
Brooklyn ...	19,622,061	20,986,473	1,364,412	7.0
Bronx	1,669,010	2,157,241	488,231	29.3
Queens	1,271,126	1,430,102	158,976	12.5
Richmond ...	750,014	790,075	40,061	5.3
Total....	61,515,046	63,494,354	1,979,308	3.2

*Decrease.

The most noticeable fact about this summary is

TABLE I.—TRAFFIC ON STREET RAILWAY LINES, BOROUGH OF MANHATTAN.

Cash Fares.	1905.	1906.	Increase.	Percentage Increase.
Surface—New York City Railway Company.....	100,603,750	100,632,318	28,568	0.03%
Elevated—Manhattan Division	56,576,312	62,853,472	6,277,160	11.1 %
Subway—Subway Division	22,005,369	27,541,692	5,536,323	25.2 %
Total.....	179,185,431	191,027,482	11,842,051	

Car Mileage.	1905.	1906.	Decrease.	Increase.	Percentage.
Surface—New York City Railway Company.....	15,658,977	14,535,082	1,123,895		7.2%
Elevated—Manhattan Division	15,552,627	15,194,758	357,869		2.3%
Subway—Subway Division	6,991,231	8,400,623		1,409,392	20.2%
Total.....	38,202,835	38,130,463	72,372		

the disproportionate increase of the suburban traffic over the urban. From the report it appears that the overcrowding of the cars in Brooklyn, the Bronx and Queens had not increased during the past year, but that in the Borough of Manhattan an increase of fares of 6.6% was carried by a decreased car-mileage of 0.2%. The same tendency toward overcrowding is noticed in Richmond Borough.

SAW-TOOTH ROOFS FOR FACTORIES.*

By Knight C. Richmond,† Jun. M. Am. Soc. M. E.

By a saw-tooth, as applied to roofs, we generally mean a form of skylight, a cross-section of which approximates a 30° x 60° draftsman's triangle with the hypothenuse horizontal, the right angle at the top, the glass in the short leg only, and the long leg forming the roof proper. Such saw-teeth can be used singly of any convenient length, in successive rows, or in any desired combination to fit particular conditions. The ridges at the peaks of the saw-teeth may run across the building, or lengthwise of the building, or diagonally, as best suits the requirements of a given case. The object of saw-tooth lights is to obtain overhead light, and in most cases the windows of the saw-teeth are placed facing directly or nearly north, and the angle of the window with the vertical made so small that direct sunlight cannot enter.

The saw-tooth form for factory lighting was first developed, I believe, in England, whence it spread to the continent of Europe, and some time in the seventies began to be used in the textile mills of the Philadelphia district.

At present, this form of roof lighting has found wide application in many kinds of factory service. Wherever the space to be lighted is of large floor area, and the occupancy such as to require only comparatively low head room, say from 11 to 20 ft., and where it is desirable to avoid direct sunlight, while still obtaining an abundance of almost perfectly diffused light, there seems to be a use for saw-tooth roofs. Such conditions occur in textile mills, especially in the weaving rooms; in dye houses where light is necessary for the careful matching of shades; in drafting rooms, in many classes of machine shops, and in a great variety of light manufacturing.

In heavy machine works, where rooms are of height sufficient to accommodate traveling cranes, and buildings are relatively narrow, say not over 100 or 125 ft. wide, and where a large amount of high light can be provided by side windows, and the direct light from roof skylights glazed with some form of diffusive glass or translucent fabric, there seems to be little use or argument for saw-tooth roofs.

The purpose of the saw-tooth form of lighting being, in most cases, to provide direct skylight in large quantity, and at the same time to avoid direct sunlight as far as possible, it follows that north of the tropics the saw-tooth windows must face nearly north, and the angle of the sash with the vertical be made dependent on the latitude of the location, the angle increasing the further we go north. In the latitude of New York, about 41°, this would mean an angle of only 17° to 18°, to keep out the sun in the longest summer days, were it not for the small projecting cornice above the window, and the internal stool or gutter at the bottom. These projections enable us to make the angle of the glass with the vertical greater than we otherwise could do, and with the form of setting and trimming frequently adopted, angles from 25° to 30° have proved satisfactory in practice in New York and New England. The angle of the glass with the vertical could be made much greater, and still keep out direct sunlight, if the cornice above the windows were extended, or a screen or barrier run along the crests of the saw-teeth.

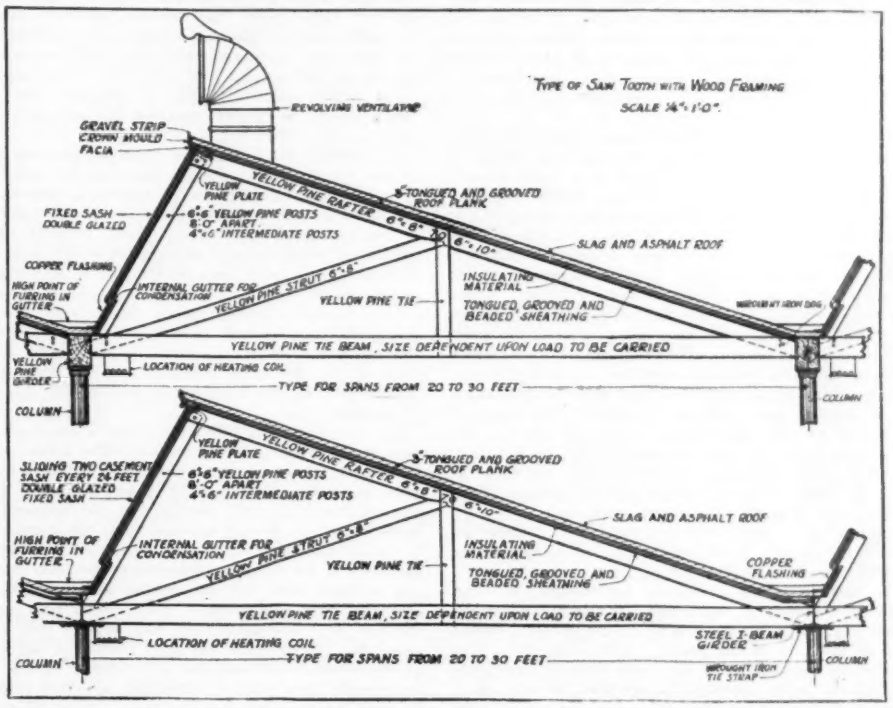
TYPE OF SAW TOOTH WITH WOOD FRAMING
SCALE ¼"=1'-0"
REVOLVING VENTILATOR
GRAVEL STRIP
CROWN MOULD
FACIA
YELLOW PINE PLATE
YELLOW PINE RAFTER 6"x8"
3" TONGUED AND GROOVED ROOF PLANK
FIXED SASH DOUBLE GLAZED
6"x6" YELLOW PINE POSTS 8'-0" APART 4"x6" INTERMEDIATE POSTS
SLAG AND ASPHALT ROOF
COPPER FLASHING
HIGH POINT OF FURRING IN GUTTER
INTERNAL GUTTER FOR CONDENSATION
YELLOW PINE STRUT 6"x8"
YELLOW PINE TIE
INSULATING MATERIAL
TONGUED, GROOVED AND BEADED SHEATHING
YELLOW PINE TIE BEAM, SIZE DEPENDENT UPON LOAD TO BE CARRIED
YELLOW PINE GIRDER
LOCATION OF HEATING COIL
TYPE FOR SPANS FROM 20 TO 30 FEET
COLUMN
SLIDING TWO CASEMENT SASH EVERY 24 FEET DOUBLE GLAZED FIXED SASH
STEEL I-BEAM GIRDER
BROUGHT IRON TIE STRAP

FIG. 2. TYPES OF WOOD FRAMED SAW-TEETH FOR SPANS FROM 20 TO 30 FT.

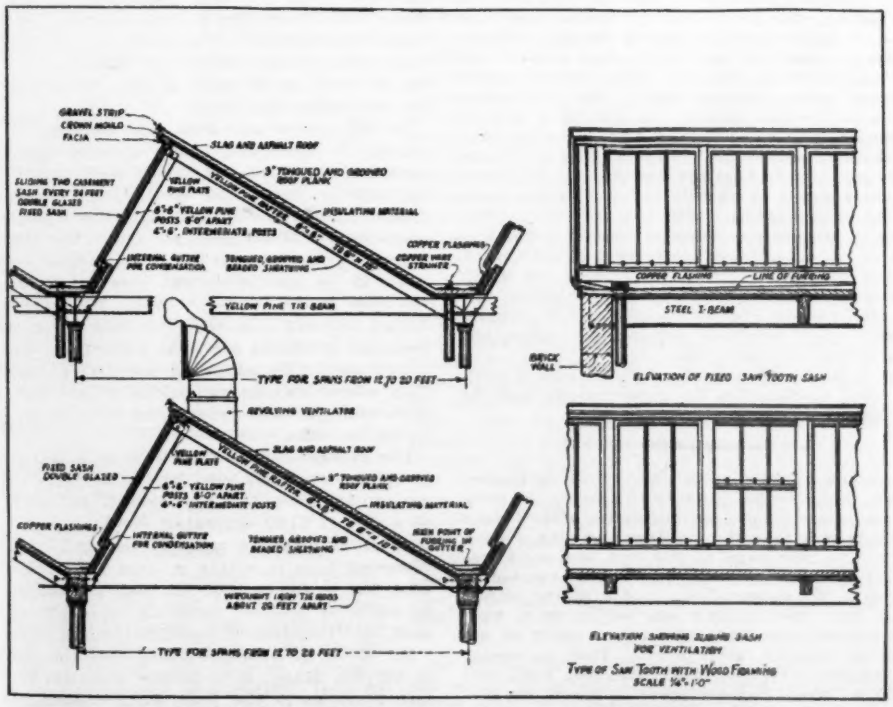
GRAVEL STRIP
CROWN MOULD
FACIA
SLAG AND ASPHALT ROOF
3" TONGUED AND GROOVED ROOF PLANK
SLIDING TWO CASEMENT SASH EVERY 24 FEET DOUBLE GLAZED FIXED SASH
YELLOW PINE PLATE
6"x6" YELLOW PINE POSTS 8'-0" APART 4"x6" INTERMEDIATE POSTS
INSULATING MATERIAL
INTERNAL GUTTER FOR CONDENSATION
TONGUED, GROOVED AND BEADED SHEATHING
COPPER FLASHING
COPPER VENT STRAINER
YELLOW PINE TIE BEAM
TYPE FOR SPANS FROM 12 TO 20 FEET
REVOLVING VENTILATOR
FIXED SASH DOUBLE GLAZED
HIGH POINT OF FURRING IN GUTTER
WROUGHT IRON TIE RODS ABOUT 20 FEET APART
COPPER FLASHING
LINE OF FURRING
STEEL I-BEAM
BRICK WALL
ELEVATION OF FIXED SAW TOOTH SASH
ELEVATION SHOWING SLIDING SASH FOR VENTILATION
TYPE OF SAW TOOTH WITH WOOD FRAMING
SCALE ¼"=1'-0"

FIG. 1. TYPES OF WOOD FRAMED SAW-TEETH FOR SPANS FROM 12 TO 20 FT.

A very interesting modification of saw-tooth lighting has been made by Mr. Willard T. Hatch, M. Am. Soc. M. E., in the treatment of foundry roofs, where he has placed the glass skylights on one side only of the successive ridges of the roof, and used the continuous ventilating monitors at the peak of the ridges, as a screen to keep direct sunlight off the glass, thus making the angle of the glass with the vertical much greater than would otherwise be possible, at the same time getting the benefit of the brighter light of the upper sky in much greater degree than would be the case were the same area of glass placed more nearly vertical.

Where the angle of the glass with the vertical is made greater than a theoretical consideration of the latitude permits, for the reasons already noted, and the windows face the north, it follows that at seasons when the sun rises and sets north of the equator, that there will be a little direct sunlight on the windows for a short time after 6 a. m., and also for a little while before 6 p. m., solar time being used in the reckoning. Mill hours in the North usually begin about 6.30 a. m. and end about 6 to 6.15 p. m., or, in other words, the help work a greater number of hours after mid-day than they do before it, and where the compass points of the building are not already determined by other considerations, we can avoid in a large measure the direct light of the late afternoon sun in summer by placing the building so that the saw-teeth will face from 5° to 15° east of north, and still not have trouble from direct sunlight before bell-time in the morning.

The framing of a saw-tooth roof may be of wood, steel or reinforced concrete, or any suitable combination of the above. No unusual problems are presented other than adapting them to the case in hand, making the obstruction to light as small as practicable. The plane of such roofs is generally nearly level, or only slightly pitched, and the saw-tooth form makes the lodgment of great quantities of snow possible, for which reasons the framing should be of ample stiffness to prevent sagging and the holding of water in puddles on the roof surface. The weight of piping, shafting, motors, machinery, or equipment, to be carried, must be considered in each individual case, and provision should be made for the same in the design. The writer does not know of a saw-tooth with reinforced concrete framing, but believes it readily adaptable where fireproof construction is very desirable, as, for instance, in large drafting rooms. Reinforced concrete is reported as successfully used for roofing, and seems to combine great advantages, if lined with proper insulating material to prevent condensation.

Any form of roof covering which successfully withstands the attacks of heat, cold, wind, rain, snow, and ice, after it is applied to the steep pitch of the back of the saw-tooth, is available. "Gravel" roofs laid with crushed slag in asphalt have successfully held on slopes as steep as 6 ins. to the foot in the New England climate, and some of the prepared felted roofings have proved satisfactory. Good materials and extreme care in applying seem to be the secrets of good service on saw-tooth roofs as on others.

The usual arrangement of saw-teeth in roofs of large rooms, namely, successive rows of windows, facing north, with the backs of the saw-teeth, which form the roof proper, sloping down to the valley at the bottom of the next row of windows, makes the exposure to cold particularly severe, and due allowance must be made for this in the heating scheme. I have used a double layer of Cabot's sheathing quilt, made of dried sea-weed, between the plank and sheathing of a flat roof of a factory office, with satisfactory results, and at small expense, and the same treatment seems applicable to saw-tooth roofs. Any

*Extract of a paper presented at the New York meeting (December, 1906) of the American Society of Mechanical Engineers.

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treatment which increases the insulating power of the roof against the passage of heat, and at the same time does not increase the fire hazard, or cause dirt after it is put in, will increase the comfort of the help in both cold and hot weather, with a lessened expense for heating in cold weather.

The portion of the front of the saw-tooth directly below the window stools should be at least as thick and as well insulated as the backs of the saw-teeth, as this part of the roof forms one side of the valley between the lines of saw-teeth, and being out of the line of direct sunlight in the winter, snow will remain there longer than on other parts of the roof, with consequent chilling of the roof.

Frequently the sash are double glazed with an air space about ⅝-in. between the lights, and this is of undoubted value in keeping heat in the building in cold weather. One glazing is often done with "factory ribbed" glass, the ribs running lengthwise of the window, and the ribbed side placed toward the air space between the lights. The ribbed glass assists in the diffusion of the light, which is sometimes strong, even with a north exposure, due to reflection from clouds. In all cases where delicate shades are to be matched, insistence should be placed on having all the glazing done with white glass to avoid the greep tint of the light coming from the ordinary glass, which shows green when looked at edgewise. In spite of double glazing, there will generally be some window condensation which must be taken care of by internal gutters at the bottom of the sash. Such gutters may drain into a system of internal piping, or have an outlet under the bottom of the sash itself, draining the condensation out onto the roof, the outlet being so arranged that the warmth of the building will keep it open against freezing.

The heating of rooms with saw-tooth roofs presents no special difficulties, if the amount of glass and severe exposure are duly considered.

The ventilation and cooling in hot weather, of large rooms with saw-tooth roofs, where the height under the framing runs from about 11 to 16 ft., is a question always needing attention in the design. Such roofs have been built where the sash in the saw-teeth were all fixed sash, and the side walls contained no windows, or only small ones, and ventilation was dependent on small windows in the ends of the saw-teeth, aided by such ventilation as came from a few entrances, and the movement of air through the belt holes in the floor. In hot and muggy weather such rooms became extremely uncomfortable, and some owners have since installed steamboat, or other ventilators at the ridges of the saw-teeth with satisfactory results. Others have changed some of the fixed sash to pivoted or hinged sash, the chief objection to which is the difficulty of making them tight in driving storms, on account of their inclined position. As fans are efficient as ventilators in both hot and cold weather, and as direct radiation is more economical for factory heating than indirect acting through a fan circulation, the best service would seem to be given by installing fan capacity sufficient for adequate ventilation only, tempering the air in cold weather, and placing the main reliance for heating on direct radiation.

The flashing and draining of saw-tooth roofs have given trouble at times. The great length of flashing in the valleys between the saw-teeth gives opportunity for much expansion and contraction and the piling up of snow in the valleys. With a relatively warm roof melting the snow on the under side, a chance is given water to work up over the lower flashing, unless the flashing is of ample height and very carefully put in, and provision be made for promptly carrying off the water from the melting snow. Where the saw-teeth run across the building, the roof is often pitched from the center ridge to both sides on a slope of ¼ to ½-in. per foot, and the water carried off in conductors which run down on the inside or the outside of the outside walls. Outside conductors have proved very undesirable in New England on account of the water freezing as soon as it has passed from the warm surface of the roof to the cold outside conductor. The result is a great mass of ice, and generally a broken conductor. It is altogether desirable, in climates where water freezes in the winter, to run the conductors down on the inner face of the side walls and to make both the strainers and conductors of ample capacity to carry off any probable amount of rain or melted snow. Where the ridges of the saw-teeth run with the length of the building, water can be most conveniently removed from the valleys by conductors placed at intervals of 40 to 60 ft. apart in the valleys.

Even with the amount of light furnished by a properly proportioned saw-tooth roof, a very large gain is made by a thorough whitening of all interior surfaces, and this should never be omitted where light is of value, and where there is any probability of the paint remaining white after it is applied.

The fire hazard of saw-tooth construction presents no difficulties from the insurance point of view, as far as I can ascertain, and no discrimination in rates is made against such construction. While the serrated form in some measure prevents the free play of hose streams against the ceiling, the same form also tends to prevent the free advance of fire in a direction across the ridges of the saw-teeth, and the great number of roof windows make it possible to attack the fire at any point by hose streams from above. The very large area of many rooms with saw-tooth roofs, rooms with 100,000 to 200,000 sq. ft. or more of floor without partitions, offer the objections from the insurance point of view, made to all such large spaces, but the installation of automatic sprinklers with ample water supply in accordance with the insurance regulations, overcomes such objections as far as they affect rates. In other words, the large saw-tooth lighted room is insured at the same rate as the remainder of the factory, provided the occupancy is the same.

The amount and diffusion of light can be made almost perfect for the most exacting requirements, and this is the pre-eminent advantage of saw-tooth lighting. By no means a small economy in the use of saw-tooth roofs is the saving in time during which artificial light is needed, as compared with side-lighted rooms in factories of usual proportions. One textile mill in which a saw-tooth lighted building of very large area is near a several storied building about 90 ft. wide, the same processes being followed in both buildings, reports state that lights are lit an hour earlier in the storied building than in the saw-tooth building. As the lighting frequently runs up into hundreds of horse-power, the saving is material.

The cost is undoubtedly greater for a saw-tooth roof, than for a flat or other plane roof. The actual amount of roof is almost as great ordinarily in the saw-tooth form as in the plane form, and may be more, and in addition there is more framing, all the windows with their trimmings, all the flashing below the windows and in the internal gutters, a large amount of painting, frequently a larger cost for conducting water from the roof, and a larger cost for the heating and sprinkling, as compared with plane roofs. These items may increase the cost of a saw-tooth roof from 40% to 60% over a plane flat roof without skylights, but this can hardly be considered a fair measure, as to obtain results fairly comparable with properly designed saw-tooth lighting, the engineer must consider the whole cost of side-lighted buildings of sufficient height in the stories and sufficiently limited in width to give satisfactory light, and should also consider the whole cost of the saw-tooth lighted building. Where the work or process requires large amounts of nearly perfect light, or where the work is bettered or done at less cost by having it, the final balance of advantage seems to incline strongly toward the saw-tooth form, as is evidenced by the great increase in recent years in the use of saw-tooth lighted buildings. This is very noticeable in buildings erected for fine and fancy weaving.

The experience of the writer after an examination of the lighting effect in a very considerable number of saw-tooth lighted rooms, designed by different engineers, is that to obtain the best results, there should be no intervals between the saw-teeth. A flat place on the roof generally means a shadow, even if slight, or perhaps only a less brightly lighted area, and makes a break in the otherwise almost perfect diffusion of the light. By the same reasoning the obstruction caused by the necessary space and flashings below the windows and by the supporting girders carrying the saw-tooth frames should be kept at a minimum. With attention paid to these points, a proportion of height of window to length of span of the saw-tooth, in the ratio of 1 to 3½, or 4, gives all the light desirable in this climate, and if this ratio is exceeded it is at the expense of greater first cost for glass and a greater running cost for heating, although special conditions may make the proportions given unsuited to a given case.

Figs. 1 and 2 show types of saw-teeth framed in wood, with some details, which the writer believes meet the requirements of this latitude.

A FLOOD AT THE ROOSEVELT DAM SITE, near Phoenix, Ariz., carried 60,000 cu. ft. per sec. of water over the masonry work now in progress, without doing serious harm further than to delay the work about a month. The first stone on this dam, now being constructed by the U. S. Reclamation Service, was laid on Sept. 20 by the contractor, Mr. J. M. O'Rourke, of Galveston, Tex. The completed dam will be 294 ft. high. It is expected that some water can be stored for use during the irrigation season in 1907. There has already been completed a power canal 19½ miles long, with a drop of 220 ft., which furnishes power to operate the government cement mill in the vicinity and also power for use on the construction of the dam. There have also been completed 10,400 lin. ft. of tunnels, 40 bridges and 68 structures, such as headworks, flumes and culverts. The cement mill has produced some 43,000 bbls. of cement, and the government lumber mill, 30 miles up the canyon, has cut about 3,000,000 ft. B. M. of lumber. Road to the extent of 135 miles and 100 miles of telephone line have been constructed.

THE MAINTENANCE OF INTERMITTENT SEWAGE FILTERS IN WINTER.

[Contributed.]

At the meeting of the Sanitary Section of the Boston Society of Civil Engineers on Dec. 5, 1906, there was an interesting discussion upon the maintenance of sewage filters in winter.

Mr. Bolling, chemist in charge of the Brockton filter beds, which have been in operation since 1894, described the method of operating the filters at that place. Late in the fall the beds are furrowed, the furrows being 3 ft. apart and 12 ins. deep. The furrowing is done by means of a double mold-board plow, with an extra iron form attached to the mold-board, which shapes the ridges and prevents loose material from falling back into the furrows. The ice forming upon the surface of the sewage when the bed is flooded rests upon the tops of the ridges as the sewage recedes and protects the sand in the trenches. It has been impossible, however, to keep the frost out of the furrows in a winter of ordinary severity, and frost is found to extend to a depth of 8 or 10 ins. below the bottom of the trenches. No serious difficulty is experienced, however, in thawing this out with the applied sewage, except in portions of the beds at a considerable distance from the point of application of the sewage. A few of the beds which have been left flat have received sewage, and in no case have they been rendered entirely useless by the frost, except in the beds where the fine subsoil was not removed from the surface.

During the first eight years of the operation of the Brockton plant the sewage quickly disappeared after being applied to the furrows. Since this time the increasing amount of organic matter in the upper layers of sand has caused the rapid clogging of the surface, and the sewage will not pass through the clogging material until there is a sufficient head of sewage above the sand to force it through. Consequently, the sewage remains upon the bed practically all winter, the depth increasing as the surface clogging becomes more impervious and more head is required to force the sewage through.

The accumulation of sewage upon the beds in winter has not worked to any permanent disadvantage. The effluent differs but little from that obtained when the beds were drained between doses, but it contains a large quantity of iron, which precipitates on exposure to the air and makes the effluent unsightly. Effluents containing as much as 12 parts of iron per 100,000 are not uncommon in winter.

In 1905 several new beds were constructed, and during the succeeding winter some of these beds were left flat, while the others were furrowed in the ordinary way. All of the beds were dosed approximately every third day, the dose in all cases being 135,000 gals. per acre. The time required for the absorption of the sewage was 7 hours in the case of the flat beds and 8 hours in the case of the furrowed beds. The amount of sludge removed from the level beds in the spring averaged 246 loads per acre, while from the furrowed beds 275 loads per acre were removed. This winter was an exceptionally open one, and little difficulty was experienced from frost, even in the flat beds.

The average cost of furrowing an acre is $5.21. If the bed were left level for the winter, it would have to be plowed at a cost of $4.17 and harrowed at a cost of $1.02, a total of $5.19. The average number of loads of material removed from the furrowed beds in spring is from 200 to 400 per acre, but in the case of flat beds the sludge can be collected without removing as much of the sand, and therefore at considerably less expense.

Mr. E. R. B. Allardice stated that the practice at Clinton, Mass., is to furrow 5 of the 25 beds just previous to the time when freezing takes place, in much the same manner as that described by Mr. Bolling, the furrows being 3½ ft. apart and 15 ins. deep. When the temperature of the air at 7 a. m. is below 15° F., the total flow of sewage for the day is applied to one of these furrowed beds. When the temperature is higher, the sewage is applied to the flat beds in smaller doses. The usual dose of the furrowed beds

amounts to more than 500,000 gals. per acre, flooding the bed to a considerable depth, and before this sewage has disappeared a coating of ice some 2 ins. in thickness has formed, which remains upon the tops of the ridges. Never has the sand in the trenches become frozen to such an extent that it is not readily thawed by the next application of sewage.

The first beds are dosed at the rate of 250,000 gals. per acre per day, and they operate satisfactorily during the warmer days of winter, except after a heavy fall of snow, when the applied sewage is chilled by the snow and a heavy coating of ice forms on the sand.

In the spring, when the beds are cleaned, there are from 4 to 6 ins. of solid matter in the bottom of the furrows, which has to be removed. The quantity removed amounts to from 275 to 300 loads per acre. In 1904 eight settling tanks were built, through one of which the sewage passes before being discharged upon the beds, and by this means the quantity of solid matter which accumulates on the beds has been materially decreased, and the difficulty in operating the beds in winter diminished.

Mr. E. C. Frost, of Framingham, considers that one of the vital points in the maintenance of sewage filters in winter is to apply large doses to the beds and not to attempt to keep a large area of filtering surface open during cold weather. In Framingham the beds are planted with corn. When the stalks are cut the hills around them are about 5 ins. high. The ice forming upon the sewage rests upon the hills, and no trouble is experienced in keeping the filtering material open, if sufficiently large doses are applied.

Mr. H. P. Eddy, of Worcester, finds that better results are obtained by leaving the beds flat in winter, the chief reasons being the expense of furrowing the beds, the greater difficulty in removing the accumulated solid matter from the furrows and the objection to mixing the organic matter which accumulates near the surface of the sand with the cleaner sand beneath the surface, as is necessary in furrowing and leveling the beds.

At Worcester it is found that the beds take a greater amount of sewage in winter than in summer, due probably to the fact that a slight freezing tends to separate the grains of sand at the surface and allows the sewage to pass through more freely. The ice which forms on the sewage is kept from attaching itself to the sand by the piles of solid matter which are raked up in the fall and not removed from the beds, the piles being about 8 ft. apart. These are sufficient to hold up whatever ice forms on the sewage when the beds are flooded.

During the warmer days of winter a large force of men is employed to rake the surfaces of the beds while they are free from frost, sludge being left in the piles. In the spring, when the piles are removed, they contain about 300 cu. yds. per acre of filter beds.

Mr. X. H. Goodnough, Chief Engineer of the Massachusetts State Board of Health, stated that during the severe winter of 1903-04 there was a great falling off in the efficiency of all of the purification works in Massachusetts, as indicated by the analyses of the State Board of Health, this being true of the new beds as well as of those which had been in use for many years. The beds did not recover their efficiency during the following year, but since then there has been some improvement in the quality of the effluent.

NOTES FROM ENGINEERING SCHOOLS.

RENSSELAER POLYTECHNIC INSTITUTE.—Two new fireproof buildings have been erected upon the recently purchased land adjoining the property owned by the Institute. One of the buildings is the gift of Mr. Andrew Carnegie, and was erected at a cost of $130,000. It is to be used for an engineering building and contains, besides recitation and lecture rooms, a 60 ft. × 100 ft. drafting room. The other building is a chemical laboratory and was built at a cost of $110,000. The qualitative laboratory is 50 ft. × 80 ft. Much new equipment has been added to the different laboratories, that for the electrical laboratory including a steam turbine.

COPPER PRODUCTION IN 1905.

The accompanying table showing the production of copper in the United States for the years 1883 to 1905, inclusive, should have appeared in our issue of Dec. 6, 1906, as a part of the article with the above title printed on page 594, but due to an oversight it was omitted. These figures are taken from the statistics of the Division of Mining and Mineral Resources of the U. S. Geological Survey, and show a grand total production of 4,241,638 long tons in the 23 years.

Production of Copper in the United States, 1883-1905, Official Statistics.
[Long tons.]

Year.	Total production, United States.	Lake Superior.	Percentage of Lake Superior of total production.	Montana.	Percentage of Montana of total production.	Arizona.	Percentage of Arizona of total production.
1883.....	51,574	26,653	51.6	11,011	21.3	10,656	20.7
1884.....	64,708	30,961	47.8	19,256	29.8	11,935	18.4
1885.....	74,092	32,209	43.5	30,267	40.9	10,137	13.7
1886.....	70,430	36,124	51.3	25,382	36	6,990	9.9
1887.....	81,017	33,941	41.9	35,133	43.4	7,910	9.7
1888.....	101,054	38,604	38.2	43,704	43.2	14,195	14
1889.....	101,239	39,364	38.7	43,849	43.3	13,654	13.5
1890.....	115,906	45,273	38.9	50,437	43.5	15,524	13.4
1891.....	126,839	50,992	40.2	50,028	39.5	17,806	14
1892.....	154,018	54,999	35.7	72,860	47.3	17,160	11.1
1893.....	147,003	50,270	34.2	69,290	47.1	19,200	13.1
1894.....	156,120	51,031	32.3	81,729	51.6	19,873	12.6
1895.....	169,917	57,737	34	84,900	50	21,408	12.6
1896.....	205,384	64,073	31.2	99,071	48.2	32,500	15.8
1897.....	220,571	64,856	29.4	102,807	46.6	36,398	16.5
1898.....	235,050	66,291	28.2	92,041	39.2	49,624	21.1
1899.....	253,870	65,808	25.9	100,508	39.6	59,399	23.4
1900.....	270,588	64,908	24	120,865	44.7	52,820	19.5
1901.....	268,782	69,772	25.9	102,421	38.2	58,383	21.7
1902.....	294,428	76,165	25.9	128,975	43.8	58,547	18.2
1903.....	311,627	85,898	27.5	121,677	39.9	65,914	21.1
1904.....	362,739	92,995	25.6	133,168	36.7	85,537	23.6
1905.....	402,637	102,807	25.5	140,514	34.9	105,637	26.2

SEVEN NEW SUBWAY ROUTES for New York City, known respectively as the Seventh and Eighth Avenue route, Lexington Avenue route, Jerome Avenue subway, Fourth Avenue and Bensonhurst route, the tri-borough route connecting the Bronx, Manhattan, and Brooklyn, and eventually Coney Island, and the West Farms and White Plains route, were approved by the Board of Estimate on Dec. 7. The Rapid Transit Commission was authorized to secure bids, first, for the construction of the subways alone, and, second, for their construction and operation. The specifications, however, will not be ready for three or four weeks. As the law requires that the invitation to bidders be advertised for six weeks, the commission will not be ready to open bids before the last of February at the earliest. It was agreed to permit the advertising for bids for separate parts of the tri-borough route. Some believe that the separation of operation and construction and that the 20-year limit of the term of the franchises with the privilege of one renewal for a second 20-year term, according to the Elsberg bill, will frighten off bidders. If this proves to be the case, the Rapid Transit Commission and the city authorities will, it is understood, combine in an effort to have the Elsberg bill amended.

THE EAST RIVER TUNNEL OF THE NEW YORK subway system will celebrate the meeting of the north tunnel headings in a few days. On the afternoon of Dec. 8 a pipe was pushed through from shield to shield of the north tube, and it became possible to check the survey lines of the two headings. It is reported that a close meeting of the shields is assured. The tunnel is being built by the New York Tunnel Co., subcontractor, for the Rapid Transit Subway Construction Co., to whom the City of New York awarded the contract for the construction of the Brooklyn extension of the subway. The only existing tunnel under the East River is the tunnel of the East River Gas Co., near 70th St., Manhattan, completed in 1894. Mr. D. L. Hough, President of the New York Tunnel Co., was Chief Engineer of the gas company at the time that tunnel was built.

AN EXPLOSION OF DYNAMITE in a powder magazine located on the first level of the No. 8 shaft of the Quincy mine, at Houghton, Mich., Dec. 5, killed 40 miners, according to press reports. The men were being lowered into the mine, in a large cage, and were about 100 ft. from the surface and passing the first level when the explosion occurred. Not a trace of the miners could be found after the accident, while several hundred feet of the shaft were badly wrecked. At the time of the explosion there was stored in the magazine several thousand tons of dynamite, all of which exploded. The cause of the explosion is unknown. No miners were working in the vicinity of the magazine at the time of the accident.

THE COLORADO RIVER BROKE FROM ITS BANKS again on or about Dec. 10, and resumed its flow through the Imperial Valley into the Salton Sea, in Southern California. It was only about Nov. 1 that the river was reported as confined to its banks, after many months of effort, numerous failures, and the expenditure, it is reported, of vast sums by the Southern Pacific Railway and allied interests. The concrete dam and steel gates recently completed to control the river are reported to be uninjured, the river having broken through the bank at another place. It is also said that the Southern Pacific will again be compelled to change its track location, near the Salton Sea, to a higher elevation. Information regarding the earlier breaks, efforts to control them and allied matters, was published in our issues of Feb. 16, March 15 (p. 300), May 10, June 28 (p. 721), and Nov. 1 (p. 465), 1906.

THE BURNING OF A STONE RESIDENCE caused eight deaths at Ithaca, N. Y., on Friday morning, Dec. 7. The building was occupied by a Cornell student fraternity. It was a three-story structure, with brick and stone walls and partitions except that the third-story partitions were of wood. The floors were of wood. A fire which was discovered shortly before 4 a. m., traveled up the two stairways and filled the third story where most of the occupants slept, with fire and smoke. Fire fighting was not started for over an hour, due to slowness in the fire department and lack of fire pressure in the mains. A wind of 20 to 25 miles per hour made the spread of the fire more rapid. Even allowing for all these facts, the spread of the fire seems to have been exceptionally rapid, and the fire unusually intense. Apparently no means of fire escape were provided. The house was luxuriously equipped, but seems to have had very low fire resistance. Two students were burned to death in the building, and three were so badly injured that they died later. The fall of an exterior wall killed three firemen. The house was built about 1880. W. H. Miller, of Ithaca, was the architect.

A FLOOD, caused by the breaking of the reservoir dam of the Detroit Copper Co. at Clifton, Ariz., Dec. 4, wrecked the business section of the town, seriously damaged the smelting plant of the Arizona Copper Co., and killed some 18 people. The property lost is estimated at $100,000. The heavy rain, which caused the breaking of the dam, lasted for 34 hours, and caused many other streams in that section of Arizona to rise rapidly and do much damage. The railway bridge over the Gila River at San Carlos, Ariz., was carried away, while many miles of the Arizona & New Mexico Ry. were destroyed.

THE PANAMA CANAL BIDS are not to be opened until Jan. 12. The official statement concerning the postponement reads as follows:

On account of certain changes made at the instance of a number of contractors in the invitation and form of contract required to be executed by the successful bidder under the invitation for the completion of the construction of the Panama Canal issued by the Isthmian Canal Commission Oct. 9, 1906, the date of opening bids has been postponed from Dec. 12 to 12 o'clock m., Jan. 12, 1907. The invitation and form of contract, with the changes made therein, will be held in the office of the Isthmian Canal Commission at Washington, D. C., subject to inspection by all contractors or others interested therein until Dec. 15, on which day in their final form they will be formally reissued.

The changes contemplated by the Commission are reported to be a reduction of the amount of the bond required from $3,000,000 to $2,000,000; the omission of the clause making the contractor responsible for defective material incorporated in the work; and provision for revision of the official estimate of cost in case of changes in the wage scale or important changes in the material encountered compared with that assumed by the engineering committee in making up its estimates of cost.

THE TURBINE STEAMSHIP, "Yale," of the Metropolitan Steamship Line, was successfully launched at the yards of the Delaware Iron Works, Chester, Pa., Dec. 1. The "Yale" and a sister ship, the "Harvard," which is soon to be launched at the same yards, are designed to be the fastest steamships in the coastwise service of the United States. They will be put in service next June on the route between New York City and Boston and are expected to cover the distance in 15 hours. Each boat will be driven by 10,000-HP. triple turbines at a speed of 23 knots per hour. These ships are of steel construction throughout, 407 ft. long, 63 ft. beam, over guards, and have a draft of 16 ft. They will accommodate 600 passengers.

PERSONALS.

Mr. Nathaniel Haven has resigned as President of the Baltimore Bridge Co.

Mr. E. H. Holden has been appointed Assistant Superintendent of the Rio Grande Western Ry. to succeed Mr. B. A. Campbell.

Mr. Henry C. Starr, of Richmond, Ind., has been elected Vice-President and General Attorney of the Wisconsin Central Ry.

Mr. Colin Craig-Loggie, late with the H. C. Frick Coke Co., has become Assistant Engineer of The Mingo Block Coal Co., Williamson, W. Va.

Mr. Adrian H. Joline, of New York City, has been elected President of the Missouri, Kansas & Texas Ry., to succeed Mr. F. N. Finney, resigned.

Mr. W. F. Costello, Assistant Superintendent of the Grand Trunk Ry. at Battle Creek, Mich., has been appointed Superintendent of the Oregon Short Line R. R. at Salt Lake City, Utah.

Lieut. H. B. Rousseau, Engineer U. S. N., has been appointed Chief of the Bureau of Yards and Docks. He will assume the office Jan. 1, if the appointment is confirmed by the Senate.

Mr. Horace Baker has been appointed General Manager, with jurisdiction over the operating and maintenance departments, of the Cincinnati, New Orleans & Texas Pacific Ry. His headquarters are at Cincinnati, Ohio.

Mr. Chester Torrance, of Havana, Cuba, has resigned as Engineer-in-Charge of Water-Works and Sewers, to form a partnership with Mr. M. P. Marceau. They will conduct a general contracting business at Maloja 2, Havana, Cuba.

Mr. W. S. Murrian, formerly General Foreman of the Union Pacific R. R. shops at Cheyenne, Wyo., has been appointed Superintendent of Motive Power and Machinery of the Middle and Western Districts of the Southern Ry., at Knoxville, Tenn.

Messrs. C. J. Grammar, C. F. Daly and Ira A. Place have been elected vice-presidents of the New York Central & Hudson River R. R. Mr. Grammar will have charge of freight traffic; Mr. Daly, passenger traffic, and Mr. Place, legal matters.

Mr. S. Henry Harrison, formerly Superintendent of Power and Machinery for the Vulcanite Portland Cement Co., Vulcanite, N. J., has accepted a position with The Osborn Engineering Co., of Cleveland, Ohio, as head of the department of cement engineering.

Mr. Mark L. Requa, Vice-President and General Manager of the Nevada Northern R. R., and General Manager of the Nevada Consolidated Mining Co., has resigned and removed from Salt Lake City, Utah, to San Francisco, Cal., where he will devote his time to private interests. He will be succeeded by Mr. Pope Yeatman, of New York City.

Mr. G. J. A. Paul, Superintendent of the Sharon & Youngstown and the Sharon & New Castle electric lines, has been appointed General Superintendent of all the lines owned by the Mahoning & Shenango Valley Traction Co. in Sharon, Youngstown, New Castle, Niles, Warren and South Sharon, Ohio. Mr. Paul becomes the first general superintendent of this company since the merging of the electric lines of the above towns.

Mr. F. H. Taylor, formerly Second Vice-President of the Westinghouse Electric & Mfg. Co., has been elected a member of the Board of Directors and Vice-President of The Yale & Towne Mfg. Co. Mr. Taylor was connected with the Westinghouse Co. for nine years, holding successively the positions of Sales Manager, Fourth Vice-President and Second Vice-President. He was at one time President of the Belmont Iron Co., and was for seven years Manager of the Philadelphia office of The Yale & Towne Company.

Mr. William Schlafge, Master Mechanic of the New York Division of the Erie R. R., has been appointed Master Car Builder, with office at Meadville, Pa., to succeed Mr. R. W. Burnett, resigned. Mr. D. Van Riper, General Foreman of the Meadville shops, has been promoted to Master Mechanic of the Rochester Division, with headquarters at Avon, N. Y., to succeed Mr. C. James, transferred to the Cincinnati Division, Galion, Ohio. Mr. J. J. Dewey, Master Mechanic of the Cincinnati Division, succeeds Mr. Schlafge as Master Mechanic of the New York Division, with headquarters at Jersey City, N. J. Mr. G. A. Moriarty, General Foreman of the Port Jervis Shops, has been appointed Master Mechanic of the Delaware Division, with headquarters at Port Jervis, N. Y.

Mr. W. W. Finley, Second Vice-President of the Southern Ry., has been elected President, to succeed the late Samuel Spencer. Mr. Finley was born at Pass Christian, Miss., in 1853, and entered the employ of the New Orleans, Jackson & Great Northern R. R. as clerk in 1876. After five years' service with this company he accepted a position with the Chicago, St. Louis & New Orleans R. R. From 1883 to 1888 he was in the freight department of the Gould System. He then went with the Panhandle Route as General Freight Agent, becoming Chairman of the Transmissouri Traffic Association in 1889. In 1890 he became Chairman of the Western Passenger Association, resigning May 20, 1892, to become General Traffic Manager of the Great Northern & Montana Central Ry. He became Commissioner of the Southern States Passenger Association in 1895, but resigned shortly afterwards to become Third Vice-President of the Southern Ry. He occupied this position for less than a year, when he resigned to become Second Vice-President of the Great Northern Ry. On Sept. 15, 1896, he returned to the Southern Ry. as Second Vice-President, which office he has since held.

Obituary.

Willis W. Polk, for many years a prominent architect of San Francisco, Cal., died at San Mateo, Cal., Nov. 29, of heart disease, aged 68 years.

Charles Donnelly, at one time Vice-President of the Baltimore & Ohio R. R., died at his home in Pittsburg, Pa., Dec. 5., of blood poisoning, following an operation, aged 67 years. He was born in Ireland but came to America when a boy. He was one of the founders of the McClure Coke Co., which was absorbed by the Frick Coke Co. in 1895.

R. R. Swisher, formerly Chief Engineer of the United Fruit Co., of Nipa Bay, Province Santiago de Cuba, died at his home in Pomona, Cal., Oct. 24, aged 50 years. He was born in Ohio, and in August, 1880, became Assistant Engineer of the Atlantic & Pacific Ry. In 1884 he was appointed Assistant Engineer of the St. Louis & San Francisco Ry., becoming Bridge Engineer of the Atchison, Topeka & Santa Fe Ry., Kiowa Extension, in 1887. He became Assistant Engineer of the Denver & Rio Grande Ry. in 1888, and from February, 1890, to July, 1892, he was connected with the Mexican Southern Ry. He then became Topographer for the Mexican National Construction Co., later becoming Locating Engineer of the Cazadero & Solis Ry. From 1894 to 1898 he was engaged in work at Chihuahua, designing waterworks, sewer system, etc. In 1899 he located and constructed the Ferrocarril Mineral de Chihuahua. He became connected with the United Fruit Co. in 1904 as Assistant Engineer, and was promoted to Chief Engineer in 1905. He was, however, soon obliged to resign this position on account of ill health and returned to California.

Rear Admiral Peter C. Asserson, U. S. N. (retired), died at his home in Brooklyn, N. Y., Dec. 6, of heart disease, aged 66 years. Admiral Asserson was born in Norway and entered the U. S. Navy as a mate in May, 1862. Shortly afterward he was made an Acting Engineer and served in this grade until 1869, when he resigned. He then took up the study of civil engineering and re-entered the Navy as Civil Engineer in 1874. Two years later he was detailed to the Norfolk Navy Yard, where he remained for nine years. He was then placed in charge of the Bureau of Yards and Docks at the Brooklyn Navy Yard, holding this position until 1901, when he was retired, having reached the age limit of 62 years. Admiral Asserson with his son, Mr. Henry R. Asserson, had lately opened offices at 59 Pearl St., New York City, as Consulting Engineers. During his connection with the U. S. Naval Corps of Civil Engineers, Admiral Asserson practically rebuilt the Norfolk and Brooklyn Navy Yards, and designed and built many timber and concrete dry-docks, quay walls, machine shops, power plants, bridges, etc., etc.

ENGINEERING SOCIETIES.

COMING MEETINGS.

ENGINEERING ASSOCIATION OF THE SOUTH.
Dec. 14-15. Annual Meeting at Atlanta, Ga. Secy., H. M. Jones, 2 Berry Blk., Nashville, Tenn.

AMERICAN ECONOMIC ASSOCIATION.
Dec. 26-28. Nineteenth Annual Meeting at Providence, R. I. Secy., Mr. Winthrop M. Daniels, Princeton, N. J.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 2, '07. Annual Meeting at New York City. Secy., L. O. Howard, Cosmos Club, Washington, D. C.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 3. Annual Meeting at Pittsburg, Pa. Secy., F. V. McMullin, 410 Pennsylvania Ave., Pittsburg, Pa.

THE AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 7-9. Annual Convention at Washington, D. C., Secy., Glenn Brown, Washington, D. C.

MICHIGAN ENGINEERING SOCIETY.
Jan. 8. Annual Convention at Detroit, Mich. Secy., F. Hodgman, Climax, Mich.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 8-11. Annual Meeting at Chicago, Ill. Secy., W. W. Curtis, 585 Caxton Bldg., Chicago, Ill.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Jan. 9. Annual Meeting at Boston, Mass. Secy., Mr. Willard Kent, Narragansett Pier, R. I.

WOOD PRESERVERS' ASSOCIATION.
Jan. 15. Annual Meeting at Memphis, Tenn. Secy., C. W. Berry, Laramie, Wyo.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 16-17. Annual Meeting at New York City. Secy., C. W. Hunt, 220 West 57th St., New York.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.
Jan. 16-18. Annual Convention at St. Paul, Minn. Secy., Martin T. Roche, 410 Pioneer Press Bldg., St. Paul, Minn.

INDIANA ENGINEERING SOCIETY.
Jan. 17-19. Annual Meeting at Indianapolis. Secy., C. C. Brown, Commercial Club Building, Indianapolis, Ind.

THE ENGINEERS' CLUB OF PHILADELPHIA.
Jan. 19. Annual Meeting at Philadelphia. Secy., Walter Loring Webb, 1122 Girard St., Philadelphia, Pa.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 23-25. Annual Meeting at Peoria, Ill. Secy., E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 29. Annual Meeting at Montreal. Secy., Prof. C. H. McLeod, 877 Dorchester St., Montreal, Quebec.

THE NATIONAL BRICK MANUFACTURERS ASSOCIATION.
Feb. 4-16. National Convention at St. Louis, Mo. Secy., Theo. A. Randall, Indianapolis, Ind.

NEW ENGLAND GAS ASSOCIATION.
Feb. 21. Annual Meeting at Boston, Mass. Secy., N. W. Gifford, East Boston, Mass.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 26. Annual Meeting at Toronto. Secy., Killaly Gamble, 405 Temple Bldg., Toronto, Ont.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.—The annual convention of the association will be held Jan. 16-18, in the new Auditorium, St. Paul, Minn. The association extends a general invitation to all architects and engineers to exhibit drawings, photographs, etc., of concrete buildings, bridges, viaducts, dams, reservoirs and other work in which concrete is used. Space for such exhibits will be reserved free of charge by applying to the Secretary, Mr. Martin T. Roche, 410 Pioneer Press Bldg., St. Paul, Minn.

BROOKLYN ENGINEERS' CLUB.—The annual meeting of the club will be held at the Club Rooms in the Brooklyn Library Building, 197 Montague St., Brooklyn, N. Y., Thursday evening, Dec. 13, at eight o'clock. Besides the reading of the reports of committees, officers and directors, there will occur the election of officers for the ensuing year. The nominations are as follows: President, Mr. Clarence D. Pollock; Vice-President, Mr. Kingsley L. Martin; Secretary, Mr. Joseph Strachan; Treasurer, Mr. John Middleton; Directors, Messrs. James C. Meem and E. Conway Shaler. The annual dinner of the club will be held at the Pouch Gallery, 345 Clinton Ave., Brooklyn, Dec. 20, at 7 P. M.

UNDERWRITERS' NATIONAL ELECTRIC ASSOCIATION.—The annual meeting of the Electrical Committee of the association will be held next March in New York City. The principal matter for consideration will be the provisions of the National Electrical Code as they now exist. This committee requests that any desired change in, or addition to, the Code be forwarded to the secretary of the association, Mr. C. M. Goddard, 55 Kilby St., Boston, Mass., on or before February 1st, in order that it may be printed in the bulletin, thus giving the committee and other interested parties an opportunity to consider the same in advance of the annual meeting. Final action on suggestions not received in season for consideration by the committee previous to the meeting, may only be taken by unanimous consent. The meeting will be open to all interested people, and such persons are urged to be present and give the committee the advantage of their experience and advice.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—The regular business meeting of the Association was held at its house Wednesday, Dec. 5, President F. P. Stearns in the chair. A paper on "The Atchafalaya River: Some of Its Peculiar Physical Characteristics," by J. A. Ockerson, Member Mississippi River Commission, was read. The so-called "Atchafalaya Problem," i. e., the question of the origin and the problem of the regulation of the river, was discussed by Messrs. A. L. Dabney, F. M. Kerr and H. B. Richardson. A paper on "The Naval Floating Dock: Its Advantages, Design and Construction," by Leonard M. Cox, Civil Engineer, U. S. N., was also read. The comparative cost of graving and floating docks was discussed by Mr. J. R. Baterden, M. Inst., C. E., and the relation of the dock "Dewey" described in the paper to some docks constructed by Mr. Geo. B. Rennie in Cartagena, Spain, some fifty years ago was noted in a letter from the latter. The paper was also discussed by Messrs. C. Colson, M. Inst. C. E., and C. H. Peabody.

NATIONAL DRAINAGE ASSOCIATION.—A national conference of drainage interests, which resulted in the formation of the above association, was held at Oklahoma City, Okla., Dec. 8. One of the principal objects of the association is the creation of sentiment favoring the establishment of a national drainage policy by the U. S. Government, similar to its present irrigation policy. The active work of the association will be under the immediate supervision of an executive committee, whose headquarters will probably be established at Washington, D. C. Representatives of the U. S. Reclamation Service and the U. S. Department of Agriculture, besides several State Engineers and engineers of State drainage commissions were in attendance at the meeting. A number of civil and municipal engineers and county surveyors of the new State, attending the conference, improved the opportunity to organize a new engineering society, to be known as the Oklahoma Engineers' and Surveyors' Society. Mr. A. G. Bernard, of Bass Lake, Minn., was elected Chairman of the Executive Committee of the Drainage Association, the election of a secretary being deferred until a later date. The next annual meeting of the association will be held at St. Paul, Minn., in October, 1907.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, December 13, 1906.

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EDITORIAL.

What is a "drawbridge"? If we go back to feudal days, undoubtedly the prevailing type of movable bridge was the bascule. Crossing the moat which surrounded a fortified castle was a bridge resting in trunnions at the inner end, and probably counterweighted in one of several ways to make it easier for the men to lift and lower it. Such a drawbridge, doubtless, was referred to in the passage in "Marmion" where Lord Douglas exclaims:

> "Up drawbridge, grooms—what, Warder, ho!
> Let the portcullis fall."

With the development of modern bridge construction in the nineteenth century, the prevailing form of drawbridge became the swing-bridge, turning horizontally around a vertical axis. It is perfectly correct to call this form of bridge also a drawbridge (even though it is not *drawn* up to open it, as was its predecessor of feudal days). The Century dictionary definition of drawbridge is

> a bridge one or more sections of which can be lifted or moved aside to permit the passage of boats.

But it is not correct, by any means, to use "drawbridge" and "swingbridge" as synonymous, by restricting "drawbridge" to the horizontally-swinging type of structure. Bascules, rolling or sliding bridges, vertically lifting bridges, pontoon bridges adapted for opening and closing, all are drawbridges, by the testimony of both history and present-day usage. In current usage that part of the structure which moves to permit the passage of vessels, or in a bridge of several spans that span which contains the movable part or parts, is the "draw" or the "draw-span." We may speak of a bascule drawspan, a double-leaf rolling-lift draw, a retractile draw, a swinging draw, etc., but we may not contrast, as individual types of movable bridge, a bascule with a drawbridge, when we mean to contrast the bascule type of draw with the swinging draw.

Since the available variety of terms for engineering structures and operations is by no means too ample, care in discriminating between related technical terms is not only desirable but necessary. The case of drawbridge and swing-bridge is a particular application of this general principle.

CORRESPONDENCE.

Carpenter's Experimental Engineering: The Review Reviewed.

Sir: In the Supplement of Nov. 15, 1906, is a critical and extended review of the above-named work covering about two pages, which seems to be worthy of consideration. The reviewer criticizes the book principally for two reasons. First, that it has omitted the description of a large number of testing instruments, and second, that it contains a good deal of theoretical material which is of no use and might better have been omitted.

It is quite evident that in order to meet the approval of the reviewer the field of the book would need to be entirely changed from that occupied by it at present. The work is primarily designed for students, as stated in the preface, and an attempt is made to state fully in every case the fundamental theory which applies to the class of experiments under discussion. The particular field for which the book is designed is pointed out in the preface (2d paragraph, page V.) in which it is stated: "It is attempted in the work on Experimental Engineering to point out the relation between the fundamental theory and the experimental results where such a theory exists." It might be stated further that the description of apparatus and of processes of testing are rather put in as examples of an application of the theory than with any intention to make the book a catalogue of apparatus or a complete description of all methods and processes of testing. It is thus seen that a book of the character outlined by the reviewer would belong to an entirely different field from that for which Experimental Engineering was intended. My experience in preparing young men for successful work in the engineering profession has led me to attach great importance to broad and underlying theoretical principles. I have found that if the young man thoroughly understood the general theoretical principles underlying any kind of work on any machine, that he was able by himself to grasp the details of different methods or different machines. The value of his engineering education, in my opinion, depends on his acquaintance with general principles rather than on his knowledge of a great many special applications.

The reviewer gives his approval to boiler tests which are made without the use of steam calorimeters. I can well understand that the work on Experimental Engineering does not fulfill the demands for men who approve of boiler tests made without the use of a calorimeter; and it was never intended to meet such a demand. This statement also explains why such a reviewer considers the chapter relating to "least squares" and much of the theoretical work as entirely a waste of valuable space. The fact, however, that the book has been well received by a large number of students and engineers indicates that it serves a useful purpose in its particular field, although that field may not be the one which the reviewer considers the proper one for such a work. My own belief is that the present field covered by the work meets the demands of a larger class of people than would the field referred to by the reviewer.

It strikes me that the reviewer has not fairly classified the amount of space given to different subjects. As an illustration, he states that a great deal of space is given to the discussion of methods of determining "moisture in steam" and very little to the subject of testing the steam engine and the steam turbine. From the standpoint of the author of the book, testing the moisture in steam, the heating value of fuels, and testing steam boilers are all incidents in the testing of the steam engine, and I believe from that standpoint the reviewer will find that the amount of space given to the subject is sufficient to meet all ordinary requirements.

The reviewer also thinks it was poor judgment to give so much space to Hirn's analysis. I can understand how such a thing seems foolish to a man who tests steam boilers without a steam calorimeter, but from the viewpoint of the engineer who desires to study the heat interchanges in a steam engine the condition would be entirely different. This latter question is a difficult one, and experience shows that even the space which is given to it is none too much to make students fully comprehend the process.

Respecting the statement that certain new instruments are not described, whereas in some cases old ones, which are not in use, are described, I would state that in many cases this has been done deliberately where the old ones were representative of a method or process, and the new one did not represent a method or process, but simply differed in detail from others in the same class.

The reviewer states that the book is in a large measure confined to a description of the apparatus in Sibley College. This statement is positively not true, although it is doubtless true that the influence due to the use of certain forms of apparatus has led to a selection as to what to describe and what to omit. It is a fact that Sibley College possesses a great deal of apparatus which is used for special and general work and not referred to in the book, and, on the other hand, a considerable portion of the apparatus referred to and described is not in use in the Sibley laboratories.

Considerable space is given to a discussion of a heading called Part II., Methods of Testing the Steam Engine, which the reviewer entirely fails to comprehend. To relieve his apprehension I would state that the leaving in of that name is due to bad proof reading. In the previous edition the work was divided into parts, and Part II. covered the methods of testing the steam engine, the term being used in its broad sense as covering all that related to engine and boiler tests, which in the present book covers nearly 360 pages. In the present edition I decided to strike out the division into parts, but either through my oversight or that of the publishers, the particular heading referred to was not cut out.

I am much pleased to have attention called to the demand for descriptions of some apparatus and processes which have been omitted; these will be taken into consideration and remedied so far as practicable when a later edition of the work is required.

The reviewer states that an error is made respecting the existence of CO in flue gas. I think in that respect that the statements in the book are correct, and agree substantially with every authority who has made a scientific investigation of the subject. I know, however, that many engineers hold to a contrary opinion, and that a number of tests are on record which show a considerable amount of CO, due principally, in my opinion, to the use of imperfect apparatus or poor methods. The statement in the book refers to the well-known law of formation of CO in the presence of an excess of oxygen, which, so far as I have been able to find, always exists under the ordinary conditions of boiler operation.

Very truly yours,

R. C. Carpenter.

Sibley College, Cornell University, Nov. 26, 1906.

Howe's Symmetrical Masonry Arches; Correction to Review.

Sir: In your issue of Nov. 15, p. 522, in the review of Howe's "Symmetrical Masonry Arches" by the writer, occurs the sentence: "If computers then decide, for similar arches, to try only two positions of the live load for approximately the maximum stresses at the abutment or at point 7, the load may first be conceived to cover three-fourths of the span." The latter part of this should read: *three-fourths of the half-span* or *three-eighths of the span*, which agrees with what is stated elsewhere. One equilibrium polygon can be drawn for full dead and live load combined at one operation; then it is easy, using part of this, to construct the polygon for dead load and the bridge three-eighths loaded as well as for dead load and bridge five-eighths loaded.

I desire to emphasize again the great value of the results given in Prof. Howe's book as to the position of the live load giving maximum stresses at any point, obtained by the consideration of single loads and ultimate summation.

In "Transactions" Am. Soc. C. E., December, 1905, Vol. LV., p. 191, the writer has a note on the subject. It may be remarked that the loadings for the segmental arches there referred to (quoted from "Theory of Voussoir Arches" by the writer) are not uniform, but locomotive and tender loadings. Respectfully,

Wm. Cain.

Chapel Hill, S. C., Nov. 19, 1906.

STATE ENGINEER OF SOUTH DAKOTA.—First Biennial Report to the Governor. 1906. (Samuel H. Lea, State Engineer.) Pierre, S. Dak.: Pub. Doc. Cloth; 6 × 9 ins.; pp. 76; three figures in the text.

The chief duties of the State Engineer of South Dakota are to see that water for irrigation is rightfully distributed to those entitled to its use. This report is largely taken up with the irrigation law of the State and with forms for applications for water rights. Some rainfall statistics and general information bearing upon the hydraulics of irrigation are also given.

REVIEWS.

The Strength of Materials.

Reviewed by Lewis J. Johnson,* M. Am. Soc. C. E.

TEXT-BOOK ON THE STRENGTH OF MATERIALS.—By S. E. Slocum, Ph. D., Professor of Applied Mechanics in the University of Cincinnati, and E. L. Hancock, M. S., Assistant Professor of Applied Mechanics in Purdue University. Boston and New York: Ginn & Co. Cloth; 6 × 9½ ins.; pp. 314; 170 illustrations, mostly in the text. $2; by mail, $2.15.

This work is one of a series of mathematical text-books edited by Percey F. Smith, Ph. D., Professor of Mathematics in the Sheffield Scientific School of Yale University. It is divided into two parts. Part I., including about two-thirds of the volume, is devoted to the mathematical analysis of the subject, and Part II., to a compilation of laboratory methods and results.

Part I., comprising as it does only about 200 pages, is a decidedly condensed treatment. It, nevertheless, finds room for considerable matter not ordinarily included in a first course in Strength of Materials, such as an analysis of stresses in hooks, links and springs, hitherto overlooked or slighted in American text-books; the principle of least work with applications; analysis of arches by the method of least work and also by the elastic theory, and the design of foundations and retaining walls. The book is so arranged, however, that students short of time may conveniently skip such portions.

The treatment of hooks and other curved pieces is interesting and valuable. One regrets that more is not stated to show how serious is the error in practical cases from the use of the more familiar but less accurate methods. The discussion of internal stresses is unusually extensive, but it is unfortunate that no mention is made of the circle of stress used so effectively by Culmann and W. Ritter as a welcome alternative if not outright improvement on the conventional algebraic methods.

The impression left after a careful reading of Part I. is that the presentation, while undoubtedly comparing favorably with that of the general run of such text-books, is disappointing; disappointing simply from a failure to rise above the commonplace level when with a little additional effort it might have been made to do so. The strong points of the book are numerous. The material is, on the whole, well selected. A fine assortment of numerical problems is furnished. Most of the presentation is good, as could hardly fail to be the case in dealing with territory so thoroughly explored.

The justification for a new book on such a subject might be expected to lie in unusual clearness and rigor of statement. Unfortunately, it is from this point of view that the worst faults of the book under review are to be seen, and while not uncommonly numerous for works of this class, these faults are none the less vexatious and likely to do harm.

One risks being charged with captiousness in taking these minor defects so seriously, but the reviewer's observations convince him that it is in the fine points that the usefulness of a text-book is made or marred. He is firmly convinced that the carelessness of teachers and writers of text-books is responsible for a far larger share of students' troubles with calculus and applied mechanics than is generally recognized.

An illustration of this kind of fault is to be found in the seriously misleading notation on pp. 71 and 72 of the book under review, where x is repeatedly used where dx should be. The result is a statement of the value of a differential in terms of characters none of them expressed in the differential form. A student cherishing the belief that a differential can be expressed only in terms of another differential here finds an apparent exception and the harm is likely to be great. It is just such things that mystify students and lead them to the hasty conclusion that the higher mathematics is too abstruse for their comprehension, when the trouble lies with the carelessness of writers and teachers.

A second illustration of a somewhat different kind of defect is to be found on p. 99, where there is a blind adherence to scholastic conventionalities which is really a regrettable failure to make the most of an opportunity—a failure hardly less vexatious in effect than an outright mistake. The differential equation from which Euler's column formula is derived is stated in the usual obscure notation

$$E\,I\,\frac{d^2y}{dx^2} + Py = 0.$$

and to integrate it, the authors say "multiply by 2 dy / dx," and cite a reference to two pages of a work on calculus to explain why. Granted that this is a customary enough treatment of the case, it must also be granted that the student gets the idea that this step could have been discovered only by a genius, and could be handled in any case in the future only by "looking the thing up." Moreover he is not at all certain when this wrinkle is introduced for integrating and when some other. Perhaps the reference cited (should he consult it) would keep him from these errors, but why cite a reference when a little care would obviate all need of it? Would it not have been better, even at the sacrifice of a little compactness and scholasticism in appearance, to keep the original equation in its unabbreviated and more intelligible form—

$$E\,I\,\frac{d\left(\frac{dy}{dx}\right)}{dx} + Py = 0$$

from which it is at once obvious that the second term may be provided with the factor dy necessary to make it an integrable expression by simply multiplying through by dy, or 2 dy if one care for such extreme finish, leaving at the same time the first term in the simplest possible form for treatment.

This kind of artificialism is rampant in elementary mathematical text-books and is a source of great harm. It does much to account for the too prevalent undergraduate notion that the natural, common-sense methods of reasoning and progress towards a desired end common to humanity outside the class-room are not in place there and that an occasional lapse into obscurity and mysticism is the hall mark of good form in mathematical instruction.

An illustration of unfortunate terminology is to be found on p. 34, where a paragraph states in substance that the theory of flexure of beams in which axial stress and torsion are assumed absent is called "the common theory of flexure." The common theory of flexure is a term which should not be thus limited to cover a mere special case, but should be reserved for greater uses, e. g., for the treatment of flexure based upon the principle of conservation of planes, and Hooke's law, which may readily and advantageously be regarded as including as other special cases pure tension or pure compression as well as the pure flexure to which our authors would limit it.

Little attention is given to any but the simplest case of flexure, in which the plane of the loads includes a principal axis of the beam section. Such treatment as is given other cases involves the awkward plan of using the principal axes, and how to get these axes is dismissed with a reference to standard works. A student is thus likely to be left wholly in the dark as to the proper treatment of a Z-bar or angle iron as commonly subjected to flexure and eccentric loading. No reference whatever is made to the product of inertia of a section—a quantity without which no adequate comprehension of moments of inertia can be had. The authors, unfortunately for the youth, are in abundant and respected company in this oversight. They are about like their competitors, no worse and, unfortunately, little, if any, better.

Five of the simpler principles relating to moments of inertia are given without proof, the student being referred to any "standard text-book on mechanics," as if the proof were too cumbersome or abstruse for ready mastery. This seems a most unfortunate and misleading omission and not a legitimate bit of condensation.

It is gratifying to see some attention given to the kernel (called in the text "core section"), but one regrets to see it treated from the unnatural, though interesting, point of view of antipolars to the central ellipse. It may easily be obtained directly as the locus of points of application of the external forces which would give rise to neutral axes touching but not crossing the beam action.

A bad lapse is found on p. 40, where the radius of gyration is spoken of as "the *average* [italics mine] value of the distances of all the infinitesimal elements of area from the axis," etc. This might not mislead, as there is a correct definition in the preceding lines, but, unluckily, the familiar word average is likely to prevent the lodgment of the less familiar though correct idea.

These examples will suffice, perhaps, to illustrate several kinds of faults which the reviewer finds in this book, as well as in others, and against which he wishes to make his protest.

Such carelessness of presentation as occurs is the more disappointing when, as in this book, special claim to rigor is made in the preface.

Part II. is practically a separate work. It is a reasonably good compilation of data on the physical properties of materials, with descriptions of testing methods and machines. There are minor crudities in this part of the work, somewhat similar to those of Part I., but the nature of the subject matter is such as to make them less important, as they are less insidious. Misapprehensions of facts of this kind gathered by young engineers from their text-books are likely soon to be corrected by their employers, or by experience, but cloudy and bewildered notions of fundamental principles, and, worse yet, a habit of tolerating such notions, produce a weakness far less readily cured.

Before dismissing Part II. one must express surprise that, at this late day, it contains a dis-

*Professor of Civil Engineering, Harvard University, Cambridge, Mass.

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cussion of reinforced concrete beam formulas confined to those based upon the existence of horizontal tensile stresses in concrete, and to see no attention given to the simple rational methods for computing shearing and adhesion stresses in such beams.

The mechanical execution of the book leaves little to be desired. It is a book whose illustrations and press work are of most attractive appearance. The proofreading is well done. There is a sufficient index.

The thought left uppermost in the reviewer's mind as a general summary of the quality of the book is that the work is little and perhaps no better than the general run of the books on mathematics and mechanics which find their way into the hands of young engineering students of the English-speaking countries. If the impression is a just one, it should be considered a serious reflection against the book. It is, of course, granted that a mature and skilled reader, hardened to petty defects, able to sift the good from the indifferent, can find much of interest in the book, but why should we rest content until only lucid, straightforward, truly scholarly and invigorating text-books be provided the student of that eminently rational profession, engineering?

Steel Mill Buildings.

Reviewed by Henry S. Jacoby.*

THE DESIGN OF STEEL MILL BUILDINGS AND THE CALCULATION OF STRESSES IN FRAMED STRUCTURES.—By Milo S. Ketchum, C. E., Assoc. M. Am. Soc. C. E., Dean of the School of Applied Science, and Professor of Civil Engineering, University of Colorado. Second Edition, enlarged. New York: The Engineering News Publishing Co. Cloth; 6 × 9 ins.; pp. 464 + 16; numerous illustrations and tables. $4, net.

The first edition of this book was issued in 1903 (see Supplement, Oct 15, 1903). It was promptly received with favor by engineers, because it supplied for the first time a systematic treatment of the details of American steel mill buildings, both as to design and construction. Valuable information was published regarding cost analyses of such structures that is not generally available to engineers, especially the younger ones, outside the estimating departments of bridge works.

Part I., which relates to loads, is increased in the new edition by adding the wind pressures and live loads for buildings recommended by C. C. Schneider in his excellent paper on the structural design of buildings, presented in 1904 to the American Society of Civil Engineers.

Four additions are made to Part II., which deals with stresses. The first of these is a brief description of influence diagrams and their use in finding a maximum moment, shear, and floor-beam reaction for a simple truss, and the corresponding criteria for the required loading. The second addition consists of the graphic treatment of the transverse bent with a ventilator and with side sheds respectively. These examples form a desirable extension of the method previously adopted, in which auxiliary truss members are temporarily substituted next to columns that otherwise are subject to bending, and thus enable the correct stresses in the truss members to be given by the stress diagrams. Although the truss and stress diagrams are considerably reduced the results plainly show that the original drawing was well arranged and executed, and that the engraver's work is properly done. The attention of designers is called to the author's very brief note that the stresses obtained are approximate, although sufficiently close to answer practical purposes, and that the exact determination of the reactions in a transverse bent must take into account the deformation of the roof truss as well as of the supporting columns. The application of this method will test the relative values of different assumptions made in finding the reactions, that are advocated in occasional discussions in engineering periodicals. The third addition shows how to find the stresses in pins by both analytic and graphic methods, and as an example the bending moments, shears and bearing are obtained for the hip pin of a bridge truss.

*Professor of Bridge Engineering, Cornell University, Ithaca, N. Y.

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The last addition to Part II. consists of a chapter on "graphic methods for calculating the deflection of beams." After explaining Mohr's method for constructing the elastic line by means of the moment diagram treated as a load, the deflection is found for a simple beam, a cantilever, and several continuous beams. This is followed by applications to obtain the reactions of drawbridge trusses with three and four supports, respectively. Some of the illustrations in this chapter are decidedly below the high standard set in the rest of the volume, and appear as if no reduction was made for the engraving. The only new matter inserted in Part III., on the details of mill buildings, gives the allowable unit pressures on foundations, masonry, wall plates, etc., quoted from C. C. Schneider's paper, previously mentioned; the report of a railroad committee on skylight construction for train sheds; and illustrations of some details of the roof arches of the United States government building at the St. Louis exposition, and of the reinforced concrete round house for the Canadian Pacific Railway at Moose Jaw, Canada. Sixteen pages of tables from manufacturers' handbooks are added at the end of the volume.

The new material that probably will most interest the teacher forms Appendix II., and consists of 22 problems in graphic statics, checked by algebraic solutions. They relate to the composition and resolution of forces, center of gravity, moment of inertia, deflection of a simple beam, and stresses in roof and bridge trusses. The complete solutions are shown in a series of full-page diagrams, accompanied by the data, equations and results. The problems give evidence of thorough preparation, and the data are so arranged that the graphic solution will be confined within the limits of the standard sheet adopted, thereby economizing the student's time.

Summarizing, the number of pages is increased from 367 to 480, and the illustrations from 185 to 233, the enlargement being confined, with but slight exceptions, to the part of the work on stresses.

KONIGLICHES MATERIALPRUFUNGSAMT (GROSS-LICHTERFELDE WEST, NEAR BERLIN). BERICHT UBER DIE TATIGKEIT DES AMTES IM BETRIEBSJAHRE 1905 [Report on the work of the Bureau in 1905].—A. Martens, Direktor. Paper; 7½ × 10½ ins.; pp. 58. Berlin: Julius Springer.

The Berlin Royal Testing Laboratory comprises separate departments for testing metals and testing-machines, for testing constructive materials, for testing paper and textiles, for making metallographic tests, for chemical tests, and for testing oils and the like. In 1905 it employed 190 persons. The extent of its work may be estimated from the fact that the department for tests of constructive materials in 1905 carried out 33,473 tests, on 884 orders of which 853 came from Germany and 31 from foreign points. The administrative and statistical report here presented contains many brief notes on the results of various items of its work during the year. Thus, 18 testing-machines were tested or calibrated during the year, and the general statement is made that

> the results with the several machines showed imperfect agreement, and it was found that in many cases the load indication was so faulty that the machines required preliminary adjustment or correction. This shows anew how necessary it is to test commercial testing-machines frequently.

Again, tests of thermal expansion of plain and reinforced concrete prisms 8 × 8 × 30 ins. gave the following results: for the plain prisms, coefficient per degree Centigrade = 94, 109, and 111 × 10^{-7} for the reinforced prisms, 101, 115, and 117 × 10^{-7}; as against 120 × 10^{-7} for steel alone.

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PART I: General Review of the Subject.—This has been added to and revised on the latest information as regards practical and experimental knowledge.

PART II: Systems Employed.—New systems have been included, and some unimportant ones omitted.

PART III: Materials.—Alterations and additions have been made, and the scope of the subject matter considerably widened.

PART IV: Practical Construction.—This section has been revised and enlarged to include the latest practice.

PART V: Experimental Research and Data Deduced Therefrom.—The experimental matter has been brought entirely up-to-date, and considerable alterations and amendments have been made.

PART VI: Calculations.—This section has been almost entirely rewritten, calculations for bending being based on straight line, stress strain curves, and considerably simplified. Diagrams for T-beams have been inserted, giving the dimensions direct. Practical examples are worked out for position of pressure curve in various types of arches. New matter has been added.

PART VII: Some Structures which have been Erected in Reinforced Concrete.—This part has been brought up-to-date, and includes interesting examples of the latest designs.

Appendix.—Further matter has been added.

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Two Practical Books by English Authors.

Reviewed by Amasa Trowbridge,* M. Am. Soc. M. E.

AIR COMPRESSORS AND BLOWING ENGINES.—Specially Adapted for Engineers. By Charles H. Innes, M. A., Lecturer on Engineering at Rutherford College, Newcastle-on-Tyne; Author of "Problems in Machine Design," "Centrifugal Pumps, Turbines, and Water Motors," "The Fan," etc. Manchester, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ x 7½ ins.; pp. 290; 285 illustrations in the text. $2, net.

MARINE ENGINEERS AND HOW TO BECOME ONE.—With Notes on the Board of Trade Examinations. By E. G. Constantine, M. Inst. M. E.; Assoc. M. Inst. C. E., etc. Second Edition. Manchester, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 5 x 7¼ ins.; pp. 332; 84 illustrations in the text. $2, net.

The first of these books is a reprint of a series of articles dealing with the theory and practice of compressing air. There is only an outline of the theory, but it is quite fully illustrated by numerical examples, so that one can readily see its application. This makes it particularly valuable to those who are not very familiar with this rather complex subject. The author considers, first, compression in a single cylinder, both isothermally and adiabatically, and explains the effects of cooling the air during compression. The compression of air in two or more stages is then considered. The theoretical part of the work is concluded with an article on loss of pressure during transmission through straight pipes. This should have been supplemented by some discussion of the loss of pressure due to bends and irregularities in the air passages. The available data on this subject are very widely scattered and such a book is the place where one should be able to find at least the most generally needed information pertaining to such losses.

The second chapter gives the outline of the results obtained on a number of tests of air compressors. These results are of distinct value to the designing engineer, as they tell what efficiencies may be expected under certain conditions.

The remainder of the book is devoted to the description of various valves, blowers and compressors. Practically all the English and continental types of compressors are described in more or less detail, also some of the more noted American machines.

While the book contains no strictly new matter, it is distinctly valuable because of the scarcity of literature dealing with this subject. There have been many important advances in this line of machinery in recent years, especially in the matter of speed. In the older compressors the piston speed was so low that the steam engine could not be very economical. This becomes a serious consideration as the price of coal advances, and the use of gas-engines appears to be desirable. The descriptions of the various blowing machines and compressors are so complete that they leave very little to be desired in this respect. Also the range of compressors described is quite complete, most of the automatic and of the mechanically-controlled valve gears being treated.

Some types of governors are also described, making the book a fairly complete compendium of modern practice in air compression.

Mr. Constantine has attacked a very large proposition in attempting to put into words the requirements for the operating Marine Engineer. His object is to furnish information of a general character, however, and this he has succeeded in doing very well. As he has been through the mill himself, he tells the beginner what to look out for and gives much good advice as to the ways to advance. To put the information into logical order, the author describes the various steps a "lad" must take to pass from the school-boy up through the various employments and grades to the rank of chief engineer. He merely outlines what is commonly called the educational part of the career, devoting most of the book to the practical part. This is, of course, due to the fact that the book is written for the one who has not had the practical experience rather than for the man who has passed through this school of practice. The book is descriptive rather than strictly scientific.

Carrying out his idea of giving clear information, the author has introduced a very good outline history of the development of the marine engine and boiler. This is desirable for another reason. One of his aims is to induce the prospective marine engineer to cultivate habits of observation and reasoning and he has endeavored to put this history into such form that it will call attention to the various steps in the progress that has been made, thus preparing the mind of the thoughtful reader to continue along the same path and develop new ideas.

A large part of the book is devoted to the enumeration and explanation of the duties of the sea-going engineer. This is both instructing and entertaining, although one must have actually performed these duties to be able to appreciate some of the points. The various breakdowns that are most likely to occur are also described, with a method for making temporary repairs for most of them.

Altogether the book is one that will tend to increase the interest of its readers in the life and duties of the sea-going engineer, besides furnishing a fund of information to the young man starting in this vocation.

*811 St. Nicholas Ave., New York City.

FOWLER'S ELECTRICAL ENGINEER'S HANDBOOK AND DIRECTORY OF LIGHT, POWER AND TRACTION STATIONS.—Manchester, England: Scientific Publishing Co. Leather; 3½ x 6¼ ins.; pp. 49 + 725; 117 illustrations in the text. 2s. 6d., net; post free, 2s. 9d. American price, $1.

With each new edition of this handbook thus far brought out a noticeable increase is made in size, due chiefly, the author states, to "the growth of electrical engineering." The present volume is nearly 100 pages larger than that of the preceding issue, and seems to have about reached the limit adaptable for pocket use. Accompanying the last increase in size is a slight increase in price, although the figure asked for the amount of information given is still a nominal one.

The book covers practically all of the branches of electrical engineering except telephony and telegraphy. The additions made since the last issue relate chiefly to electric meters, long flame arc lamps, cable and fault testing, resistance wires, measurement of illumination, testing of alternators and transformers, designing of dynamos and motors, and special types of electric lamps.

Considering the volume as a handbook it is safe to say that much of the material given on the design of magnets, dynamos and transformers, could well be omitted and this space devoted either to the branches of electrical engineering not mentioned at all or to the subject of electric traction, which is only superficially covered.

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ENGINEERING IN THE UNITED STATES.—A Report to the electors to the Gartside Scholarships [University of Manchester] on the Results of a Tour in the United States in 1904-05. By Frank Foster, M. Sc., Gartside Scholar. Manchester, England: The University Press. Cloth; 5¾ x 9 ins.; pp. 105. 1s., net; American price, 40 cts., net.

The author spent 12 months in the United States, "visiting works and educational institutions, interviewing business men, attending engineering meetings" and "as a worker in a manufacturing works and in a power station." His observations are recorded under the heads: General Engineering Policy; Relations Between Employer and Employed; Education; American Tramways; Wages and Prices; American Engineering Workshops; Electric Power Station. While intended primarily for British readers the interest of the essay to Americans will be almost as great, though chiefly for the sake of seeing ourselves as others see us. The general tone of the author is fair and kindly. He draws some lessons that might be heeded by both the British and American engineers and manufacturers. Some of these relate to technical or manufacturing details, some to the general economic principles and some to the social welfare or betterment of employees.

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Electrical Engineering Books.

Reviewed by Henry H. Norris.*

ALTERNATING CURRENTS.—A Text-Book for Students of Engineering. By C. G. Lamb, M. A., B. Sc., Assoc. M. Inst. E. E., Clare College, Cambridge. New York: Longmans, Green & Co. London, England: Edward Arnold. Cloth; 5½ x 8¼ ins.; pp. 325; 251 illustrations in the text. $3, net.

APPLIED ELECTRICITY.—A Text-Book of Electrical Engineering for Second-Year Students. By J. Paley Yorke, Head of the Physics and Electrical Engineering Department at the London County Council School of Marine Engineering, Poplar, London, E. New York: Longmans, Green & Co. London, England. Edward Arnold. Cloth; 5 x 7½ ins.; pp. 420; 153 illustrations in the text. $2.10, net.

The field of alternating currents appears to be a most attractive one for authors at the present time. New books appear at frequent intervals and as a rule they are well written. Several cover the same range of topics, and when a new work appears it is pertinent to inquire into the particular reason for writing it. In the present instance the writer has found that material on the subject of alternating currents is available only in very elaborate works or in others too greatly condensed for the purposes of instruction. His aim has been to produce a broad, general treatment of the analytical side of alternating currents, assuming on the part of the reader the following preparation:

General elementary theory of magnetism, including the idea of self-induction, the magnetic circuit, hysteresis and the laws of eddy currents.
The principles involved in the action of condensers.
The principles of direct-current machines.
The elements of the calculus, including the definite integrals of simple cases of the circular functions.
The elementary properties of vectors.

In general the graphical method is followed on the assumption that it is more readily comprehended than an algebraic treatment. No claim for originality of method or material is made, but the author has attempted to treat the standard list of topics in as complete a manner as the space will allow. He has succeeded in producing an excellent reference book for engineers, but from the reviewer's experience it is too heavy a text for undergraduates. As the book has been written primarily for students it must be viewed from their standpoint. This class of readers requires (1) that instruction be practical and (2) that the application of each principle be made at once by means of illustrative problems and experiments. In this important feature the book is only partially satisfactory, but it is entirely so both in arrangement and in technical detail.

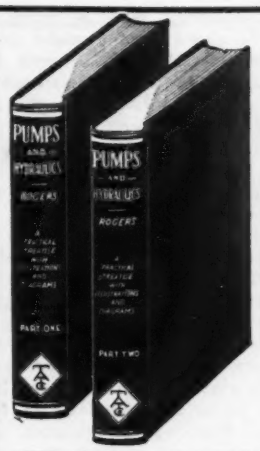
The space is equitably divided among such important topics as the alternator, induction and synchronous motors, transformers and measurements. Armature reaction is fully treated and the discussion throughout applies to modern types of apparatus. There is little description of actual apparatus, the practical details being left to the reader's engineering experience or to the reading of current technical literature. The work is very similar to that of Dr. Alfred Hay† under the same title. The two authors enlarge upon different details so that their work is more or less complementary. Both books differ in many ways from other standard treatises upon the same subject. Such books as these tend to standardize the literature of electrical engineering, and the time for the production of such standard text has arrived. Although the "infancy" of electrical applications is still occasionally referred to by the uninformed, practical engineers realize that certain principles are now well established. Hence it is entirely safe to put these into permanent form where they can be referred to as the basis for advanced study.

Electrical books are produced by two classes of writers, namely, physicists and engineers. The former treat largely of the science, the latter the art of the subject. The scientist deals with underlying principles, while the engineer shows how these are applied. In practically all the engineering books the two elements are combined, but a casual glance indicates the bent and training of the writer. Thus Mr. Yorke's book, even when dealing with practical topics, shows minuteness of detail rather than general perspective. It covers a course in electricity such as would be given in connection with the study of physics in the universities of this country. For this reason the name is rather misleading, as the book deals more with the theory than with the application of electrical principles. There are, however, several instances where practical matters are mentioned, but the treatment is not complete enough to make much impression. In fairness to the author it should be said that his book was written for students in their second year of acquaintance with electrical matters. He intends it to lead up to special branches of electrical work, "such as electrical machine design, alternate current work, and the like." It does seem, however, as if the student would be more interested in the subject were he first given at least a general personal knowledge of the different kinds of devices used in practice. The study would then be less "dry" and tedious than it often is.

The book contains a large amount of excellent information presented in an informal readable style. The arrangement is systematic and little of mathematics is introduced. A person with an elementary knowledge of electricity and magnetism should have no trouble in reading it, particularly if he is practically familiar with dynamos, motors, arc lamps and other devices. To such readers it will be of the greatest assistance in indicating the reasons for much that they could not otherwise understand. The text is fairly well illustrated, but for the beginner it contains too many diagrams and too few pictures of actual apparatus. The volume is well printed and strongly bound, and it has an advantage over some other works in that the price is moderate. It covers very much the same field as Parr's "Electrical Engineering in Theory and Practice,"* but the latter is in many ways superior in that it is more general. It is probably intended for more advanced students than is Mr. Yorke's book. It is interesting to compare Yorke's "Applied Electricity" with Aryton's "Practical Electricity," written about twenty years ago, when the latter was one of the very few text-books available. Since that time electrical engineering has made great progress and the text-books have kept pace with the demand for first class instruction.

*Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.
†Reviewed on p. 430, Vol. LV., April 12, 1906.

*Reviewed on p. 55, Vol. LVI., No. 2.



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Turbines; Energy Chart; Gas Engines.

Reviewed by Storm Bull.*

THE THEORY OF THE STEAM TURBINE.—A Treatise on the Principles of Construction of the Steam Turbine, with Historical Notes on Its Development. By Alexander Jude. London, England: Charles Griffin & Co., Ltd. Philadelphia, Pa.: J. B. Lippincott Co. Cloth; 6 × 9 ins.; pp. 296; 252 illustrations, mostly in the text; 3 folding plates and 19 tables. $5, net.

THE ENERGY CHART.—Practical Applications to Reciprocating Steam-Engines. By Captain H. Riall Sankey, R. E. (ret.), M. Inst. C. E., M. Inst. M. E. Rugby, England: Albert Frost & Sons. Cloth; 5½ × 8½ ins.; pp. 170; 157 illustrations in the text and one folding plate.

DER DRUCK AUF DEN SPURZAPFEN DER REAKTIONSTURBINEN UND KREISELPUMPEN.—Studies by Dr. Karl Kobes, Professor in the Technical College at Vienna. Leipzig and Vienna: Franz Deuticke. Paper; 6¾ × 10½ ins.; pp. 174; 62 illustrations, partly in the text. 6 marks; American price, $2.40.

ELEMENTS OF GAS ENGINE DESIGN.—By Sanford A. Moss, M. S., Ph. D., M. Am. Soc. M. E., Engineer, General Electric Co. Reprint of a Set of Notes Accompanying a Course of Lectures Delivered at Cornell University in 1902, and of Articles from "American Machinist," "Machinery" and "Power." With Additions. No. 121, Science Series. New York: D. Van Nostrand Co. Boards; 3¾ × 6 ins.; pp. 197. 50 cts.

The title of Mr. Jude's book is hardly satisfactory. The theory of the steam turbine forms altogether the least essential part of the book, whereas the principles that should govern the design form its most important portion. There cannot be any question but that the book has been written for the use of the designers of turbines, and the information furnished—both as to quality and quantity—is such that the book should prove very useful to this class of engineers. The most important chapter titles are: Historical Notes on Turbines; Velocity of Steam; Types of Steam Turbines; Practical Turbines; Efficiency of Turbines; Turbine Vanes; Disk and Vane Friction in Turbines; Strength of Rotating Disks; Governing Steam Turbines; Steam Consumption of Turbines; The Whirling of Shafts; Speed of Turbines.

Some of these chapters, like the ones on types of turbines and practical turbines, are very good indeed, giving, as they do, in a condensed form all that is really important on the subjects treated. Both of these chapters are well illustrated and the book is remarkably free from "pictures," there being in the whole book no half-tones from photographs of turbines or their parts. The three chapters on the efficiency of the various kinds of turbines are also very satisfactory, all statements and rules being accompanied by numerical examples. In the chapter on disk and vane friction the author has brought together in a very condensed form the most reliable data regarding these subjects, and in the chapter on the strength of rotating disks he gives a thorough and very mathematical discussion of this intricate subject. The reviewer is certain that most practising engineers would turn up their noses at the sight of expressions involving both differential equations and calculus. It seems that the author has devoted altogether too much space to this subject when it is remembered how brief he is in other directions: for instance, in the chapter on the whirling of shafts, a matter which is of equal importance with that of the strength of the disks. The chapter on the steam consumption of turbines contains a number of tables in which the results of tests of various kinds of turbines are given; also a larger number of graphical charts of such tests and similar tables and charts for the reciprocating engine. A very interesting chart is given on which the efficiencies of the turbine and reciprocating steam engine are the ordinates and the back pressures under which they were working are the abscissae. From this chart it would seem that it is only with a back pressure of 1½ lbs. or less that the steam turbine can compete in efficiency with the reciprocating engine. A chapter on the specific heat of superheated steam seems rather out of place in the book, even if it be true, as the author states in his preface, that lack of knowledge on this subject has made many results of tests of turbines and engines quite contradictory. The first chapter, the title of which is "Fundamental," seems also out of place, to a great extent, at least. Anybody who is going to make a study of the steam turbine ought to be familiar with Bernouilli's theorem, or with the first principles of hydraulics, subjects treated in this first chapter, and, as it seems to the reviewer, in rather a crude manner.

But as stated above, the book is, on the whole, very satisfactory. It is well gotten up and the large number of numerical examples worked out add materially to its value.

To those who are acquainted with the educational facilities offered to the engineering profession in Great Britain it seems very strange that it was in that country that the temperature-entropy diagram first found an extended use among mechanical engineers. But this is a fact, and a proof of this statement is found in the publication in book form, but especially in the proceedings of the Engineering Societies, of treatises on the temperature-entropy diagram. Captain Sankey's book is a very welcome addition to the literature on the subject. It is remarkably clearly written, so that upon reading of the book the terrible "bugbear" of the expression entropy very soon disappears. As will be noticed, the author gives the diagram a new name—the energy chart—and the reviewer is of the opinion that it is a very good name, indeed, as it tells exactly what is obtained by means of the chart.

The first chapters give the relation of the energy chart to the thermodynamics of steam and gases, and the last ones comprise the practical application of the chart to the reciprocating engine, both single cylinder and compound. The author is thoroughly familiar with his subject, and not least in its practical applications. There can be no doubt that the book as a whole, and especially the last part, will prove useful to all engineers interested in either the design or testing of steam engines. It is very much to be hoped that the author will see his way to write a book which would give the application of the energy chart to the steam turbine in as satisfactory a manner as has been done in this book for the reciprocating engine. It should be noted that he has shown in this book how the computation of the dimensions of a new engine may be based on the energy chart, a new application of the chart, as far as the reviewer knows. From the title page it is seen that the author is "retired." It would be a fine thing if our engineers could "retire" early enough to enable them to use their energy and ability to produce books of such high value as that of Captain Sankey.

Dr. Kobes' book, which is a partial reprint from the "Zeitschrift des Oesterreichischen Ingenieur und Architektenvereins" of the years 1905 and 1906, is an excellent example of the thoroughness which generally characterizes the German professor. At the same time, it would also seem to exemplify a weakness of quite a few German books: too much theory simply for the sake of working out special problems. The title of the book does not adequately describe its contents, for it contains in a more or less complete form the theory of the turbine, both as understood heretofore and also according to the so-called "new theory," as promulgated by Prasil and Lorenz in the "Schweizerische Bauzeitung," "Zeitschrift des Vereins Deutscher Ingenieure," and in the "Zeitschrift fur das gesammte Turbinenwesen." The book is a very interesting one, especially to those who are theoretically inclined. It also contains some numerical examples of the pressure on the step-bearing, and also some examples relating to the complete turbine. The illustrations, both in the text and on plates, are exceptionally fine and could serve as examples for our publishers. In other respects, also, the make-up of the book is unusually satisfactory.

Dr. Moss's book is one of the best of the Science Series of the Van Nostrand Co. It is obvious that in such a small compass it is impossible to go to the bottom of everything or even touch upon all the elements treated in a complete treatise and the design of the gas engine. But as far as it goes the book is sound. It is clearly written, and to a beginner in this line it should prove very valuable. The price is so moderate that no doubt it will find a wide sale.

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

GEOLOGICAL SURVEY OF NEW JERSEY.—Annual Report of the State Geologist for the Year 1905. (Henry B. Kümmel, State Geologist.) Trenton, N. J.: Pub. Doc. Boards; 5¾ × 9 ins.; pp. 338; 30 plates (3 in pocket) and 21 text illustrations.

The reports of the State Geologist of New Jersey have been rendered unusually interesting to engineers, for reports of this kind, by various contributions on water supply made from time to time by Mr. C. C. Vermeule. In the present report Mr. Vermeule has a very interesting discussion of "Lake Passaic Considered as a Storage Reservoir for Potable Water, Good Control and Utilization of the Passaic River." He describes a possible reservoir formed by a dam at Little Falls, 6,000 ft. in length, which would flood a maximum area of 51½ sq. mi. and would store a total of 43,824,000,000 cu. ft. of water. The report also contains a lengthy paper entitled "Changes Along the New Jersey Coast," by Lewis M. Haupt, in the course of which there is considerable information on shore protection. There is also a group of interesting papers on the peat deposits in Northern New Jersey, in the course of which the technology and uses of peat and the testing and valuation of New Jersey peats are discussed.

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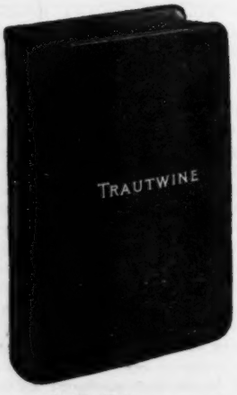

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Like all technical books, this one should be judged by its adaptability to the needs of the readers for whom it is intended. These, the author states, fall into two classes: (1) city officials with no technical education, who come in contact with engineers and engineering work and oftentimes direct both; and (2) town and city engineers, "especially those with little or no previous experience in municipal engineering." The author still further restricts himself to officials in places of less than 20,000 population, but adds, and in this we agree, that the book "may be found useful in some larger places." The book is unique, for one of its class, in the amount of information it contains on how to do things. That is, it deals largely with the execution as well as the planning and the theory of various public improvements. This is more especially true of street work, various surveys, concrete work, filing systems and records generally than of sewerage, sewage and refuse disposal and water supply.

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Personal preferences and opinions are freely expressed. In so far as these are founded on experience, as is often the case, they are generally of value, but when the author says, in effect, that to-day little is heard of garbage reduction he conveys a wrong impression. He also expresses himself in questionably sweeping terms when he says that no town or city should accept a macadamized street. This statement, in view of the large mileage of such streets being put down every year by municipalities themselves, both at home and abroad, needs more supporting evidence than the author gives to warrant its inclusion in a book designed largely for the uninformed city officials. Possibly, although we doubt it, the author is right in saying that macadam will probably disappear within a generation, except in out-of-way places, but certainly its use will be justified for a few years to come in some parts of the country.

The Suez Canal.

LE CANAL DE SUEZ.—By Voisin Bey. Paris, France: Vve Ch. Dunod. Seven volumes of text. Paper; 6 × 9¼ ins.; about 3,000 pages; 40 plates in separate volume, 9½ × 12½ ins. 90 francs; American price, $27.

This work is by the former Director of Construction of the Suez Canal, and treats exhaustively of its history, its construction works, and its permanent works. The first volumes were issued in 1902, but the final volumes have only been issued during the present year. The history of the canal is given at considerable length in three volumes, with reports of the government conventions and company's meetings, and copies of the concessions and other documents: the first volume covers the period from the first concession in 1854 to the opening on Nov. 17, 1869; the others cover the periods of operation 1870-1882 and 1883-1902 respectively. The next volume deals with the location and profile, the harbor works at Port Said and Port Suez, and the fresh-water canal. The three remaining volumes put on record the construction plant and methods employed on the various sections and by several contractors. The folding plates include maps, profiles, sections, drawings illustrating construction plant and methods, and drawings of the permanent works (jetties, dams, etc.). Some of the plans show the arrangement of construction tracks on individual sections. Drawings of proposed methods of handling the excavated material show a gravity [illegible]way, with rocking tower to raise or lower th[illegible]nd of the cable so as to run empty buckets to [illegible]aded buckets from the work. Inclined elevat[illegible] conveyors are also shown, fed by hand sho[illegible]rs or by dredges and delivering the material in[illegible] dump cars. Dredges and special appliances f[illegible] handling dredged material are also illustrated.

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A TECHNOLOGICAL AND SCIENTIFIC DICTIONARY. —Edited by G. F. Goodchild, Principal of the Wadsworth Technical Institute, and C. F. Twency, Late Librarian and Secretary, Putney Public Library. London, England: George Newnes, Ltd. Philadelphia, Pa.: J. B. Lippincott Co. Cloth; 6¾ × 10 [illegible]. pp. 875; illustrated. $6.

The various arts and sciences, rather than engineering as understood in America, are treated in this dictionary. Much space is devoted to chemistry, a fair amount of mechanical and electrical engineering, and relatively little to civil engineering. Music and heraldry are among the main topics that one might not expect to see given so much space. Among the other leading subjects included are architecture, assaying, astronomy, economic botany and zoology, building trades, geology, glass and leather manufacture, hygiene, metallurgy, mineralogy, motor cars,

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The thoroughly British point of view of the compil[er] is indicated by such a statement as this: "The file is one of the principal tools of the engineer and of other metal workers." Almost as strange to many of our readers is the unqualified assertion that timber piles are square in section. A positive error occurs in the paragraph on "Filtration," where it is stated that in large municipal sand filters "the water is introduced *from below*." The context is at variance with this statement.

The physical make-up of the book is generally satisfactory, its poorest feature being a portion of the illustrations, some of the line diagrams and woodcuts being badly blurred.

Hydraulic Power Development.

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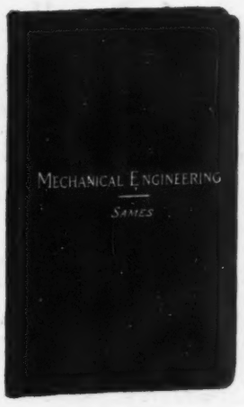
A MANUAL OF HYDRAULICS.—By R. Busquet, Professor in the Industrial School at Lyon (France). Translated by A. H. Peake, M. A., Demonstrator in Mechanism and Applied Mechanics in the University of Cambridge. New York: Longmans, Green & Co. London, England: Edward Arnold. Cloth; 4¾ × 7¼ ins.; pp. 312; 47 illustrations in the text. $2.10, net.

The five chapters of this book are entitled Fundamental Laws, Flow of Liquids in Delivery Pipes, Flow of Liquids in Open Canals, Hydraulic Engines, and Construction of a Waterfall. The theories and discussions are quite ancient, most of the formulas and coefficients for the flow of water being those set forth by Dupuit and Prony a century or more ago. The formula for flow in open channels established by Darcy and Bazin in 1860 is mentioned, but no note is made of the later valuable investigations of Bazin, nor of those of Kutter. The discussions are very elementary, so much so that the quadratic equation on page 44 is treated by an indirect arithmetical method, because this equation "would require for its solution the use of algebra." Large portions are copied from "L'Art de l'ingénieur," by Vigreux, an engineering cyclopedia published about 1880, and no matter of later date is found in the book, except in a few pages of the chapter on hydraulic engines. This chapter fills more than half the volume, and is devoted to water wheels, turbines and hydraulic rams. No records or discussions of hydraulic experiments are given. For dams and weirs only a single coefficient is mentioned, this being derived not from experiment but from a doubtful theory. On both the theoretical and the practical side the imperfections are so numerous that one wonders why an English translation should have been made. The author and the translator claim that the book is of value not only for technical schools but also to those engaged in the development of hydraulic power. In the opinion of the reviewer, however, it is an unsafe guide for both students and engineers.

POOR'S MANUAL OF THE RAILROADS OF THE UNITED STATES.—Street Railway and Traction Companies, Industrial and Other Corporations and Statements of the Debts of the United States, the Several States, Municipalities, etc. Thirty-ninth Annual Number, 1906. New York: Poor's Railroad Manual Co. London, England: Effingham Wilson. Cloth; 5¾ × 9 ins.; pp. xvi. + 1932; folding and other plates. $10.

Besides the usual well-known features of this volume, which include ordinary and street railways, a variety of industrial corporations, and information regarding State and municipal indebtedness, there is included in the present volume matter formerly published in the "Railroad Manual Appendix." This additional matter, relating to bonds, annual meetings, and dividends of the past eight years, together with the natural increase in size of the book, makes an addition of nearly 200 pages. The character of the "Manual" is too well known and appreciated to need explanation or comment.



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Some Elementary Phases of Sanitary Engineering.

ELEMENTS OF SANITARY ENGINEERING.—By Mansfield Merriman, Professor of Civil Engineering in Lehigh University. Third Edition, Enlarged. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 250; illustrated. $2, net.

The first edition of this text book was favorably noticed in Engineering News of Dec. 29, 1898. It appears that few changes of importance have been made in the first 180 pages of the present edition, since the pagination is the same for the various topics treated up to that point. The two chapters on "Disposal of Sewage" and "Refuse and Garbage" have been rewritten and extended to cover some of the advances of the past eight years, and an appendix has been added which contains matter on water supply and purification supplementary to that in the first edition. We are also glad to note that an index has been supplied in this edition.

Sanitary engineering, in the opening chapter, is so defined as to limit it to water supply and sewerage, and to these two subjects the book is chiefly confined, except for a few pages on street cleaning and on garbage and refuse disposal. Sanitary science, as the author himself points out, is much broader than this, and we believe that sanitary engineering really covers a larger portion of the field of sanitary science than the author assumes. As an elementary text on water supply and sewerage, more particularly from the sanitary viewpoint, but not overlooking hydraulics, the work may, for the most part, be highly commended. The information given on garbage and refuse disposal is still inadequate and far behind that in other portions of the book.

We regret to say that the author has retained on pages 13 and 14 certain misleading statements regarding specific bacteria and their relation to disease. More correct ideas are given elsewhere in the book, but it is a pity that they should not have been clearly stated at the outset. The author states that

> malaria is produced by a certain germ whose home is in swamps or lowlands; typhoid fever is caused by a germ which lives in certain fouled waters; . . . Influenza or grip is supposed to be caused by a peculiar germ which lives in fine volcanic dust, and the last epidemic of this may perhaps be due to the great eruption at Krakatoa in 1883. . . . smallpox has been known to cross a river a mile in width.

These statements fail to impart to the student the fundamental principle in communicable diseases, which is that the natural habitat of the germs that cause them is the human being and that their spread therefrom should be controlled accordingly. We can hardly understand how the statement relating to grip and volcanic dust should ever have got into the book originally, and once in that it should not have been stricken out on the first opportunity, or at least some later volcanic eruption than that of 1883 held responsible. As to smallpox crossing a river a mile in width, we raise no question, provided it be understood that a man or some infected clothing crossed with it. These of course are minor defects in the book, which is not only a creditable production but practically the only one covering just its field.

THE COPPER HANDBOOK.—A Manual of the Copper Industry of the World. Vol. VI. Compiled by Horace J. Stevens. Houghton, Mich.: Horace J. Stevens. Cloth; 6 × 9 ins.; pp. 1116. $5.

Following the chapters on the history, geology, chemistry and mineralogy, metallurgy, and uses of copper, and glossary of mining terms, the author takes up in succession the copper deposits of the United States and other parts of the world, devoting about 150 pages to all these subjects. The main portion of the book is a chapter of over 900 pages, entitled "Copper Mines of the World." The various mines are listed by their names or the names of the companies owning them. The matter under each title ranges from a line to a number of pages. For the more important mines and companies a brief history is given, accompanied by financial statistics and by descriptions of the mines and their equipments. The purely alphabetical arrangement is in some respects a very poor one, but the compiler states that experience has shown it to be the most satisfactory. In general, the descriptions are well written, and many of them are not only readable but in some parts highly interesting. The final chapter, of some 30 pages, is devoted to copper statistics.

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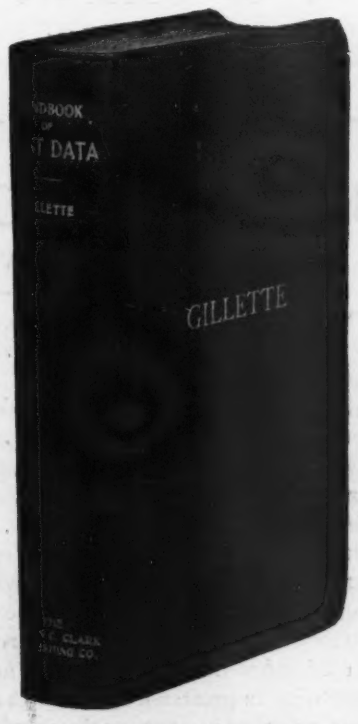

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